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THE JOURNAL OF WILDLIFE MANAGEMENT

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STATEMENT OF POLICY

According to the Constitution of The Wildlife Society, adopted at the St. Louis Meeting, February, 28, 1937, "The principal objectives of the Society shall be: (1) Establishment of professional solidarity and maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; (3) publications to effect these ends; and (4) protection of the interests of its members."

The "maintenance of the highest possible professional standards" is thus one of the obligations placed squarely upon THE JOURNAL OF WILDLIFE MANAGEMENT. The first effort towards meeting this obligation will be made in the selection of the best available material for its pages. In the opinion of the present Officers and the Editor, the JOURNAL should be devoted primarily to the publication of original articles of the highest quality obtainable, bearing on wildlife research, management, and administration. In view of the congested condition of nearly all biological publications, articles that have been published or accepted for publication elsewhere will not, as a general rule, be accepted for the JOURNAL.

In accordance with this principle, so long as the Biological Survey maintains *Wildlife Review* at its present standard no service rendered by that periodical, which is sent free to anyone who requests it, will be duplicated by THE JOURNAL OF WILDLIFE MANAGEMENT. However, critical reviews will have a place in the JOURNAL when apparently required for the welfare of the profession. Such reviews will be signed or initialled by their writers.

The "development of all types of wildlife management along sound biological lines" will, we believe, mean the suppression of some of the activities that have long been a part of American public policy toward wildlife. Politically-dictated restocking ventures and indiscriminate "vermin control" are cases in point. Management along sound biological lines means management according to the needs and capacities of the animals concerned, as related to the environmental complex in which they are managed. It does not include the sacrifice of any species for the benefit of others, though it may entail the reduction of competing forms where research shows this is necessary. It consists largely of enrichment of environment so that there shall be maximum production of the entire wildlife complex adapted to the managed areas. Wildlife management is not restricted to game management, though game management is recognized as an important branch of wildlife management. It embraces the practical ecology of all vertebrates and their plant and animal associates. While emphasis may often be placed on species of special economic importance, wildlife management along

sound biological lines is also part of the greater movement for conservation of our entire native fauna and flora.

One of the glaring faults connected with wildlife administration in this country has been the propagandizing and misrepresentation of plans as if they were things already accomplished. To offset that tendency, publication in the JOURNAL will be restricted chiefly to the results of research and of management or to worthwhile discussions of the principles and philosophy of wildlife management and administration. Plans, speculations, and prophecies will be subordinated.

We urge, as ideals to be realized as rapidly as possible, that all phases of wildlife management be based on adequate research and that all wildlife management be conducted and administered by personnel with biological training of professional grade.

As one of the publications to effect the objectives of the Society, the JOURNAL will be dedicated to them.

When protection of the interests of members is involved, the JOURNAL will be open to letters and articles defining, discussing, or defending those interests.

Rudolf Bennitt, *President*
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THE EVALUATION OF NESTING LOSSES AND JUVENILE MORTALITY OF THE RING-NECKED PHEASANT[1]

Paul L. Errington and F. N. Hamerstrom, Jr.

In the new and growing field of conservation biology, few life history phenomena have occasioned more comment than the heavy percentages of nest failures recorded for many species of birds thus far studied.

Stoddard (1931, pp. 224–225) concluded after his first 5 years of intensive study of the bob-white quail (*Colinus virginianus*) in southeastern United States that 60% to 80% of the nesting attempts could normally be expected to fail. Nevertheless, few pairs were completely unsuccessful in bringing off young, as, in the event of loss or abandonment of one or of successive clutches of eggs before hatching, renesting attempts were usually made unless the season was too late or the breeding birds were in poor condition. The heavy nesting losses, therefore, served to delay rather than to prevent the final hatching of a brood by a breeding pair, with a resulting higher percentage of immature birds by fall and a lower total hatch and percentage of young birds reared. No evidence was found that the bob-white made any effort to produce a second brood in the same season if a first was successful. Errington's (1933) data on 69 bob-white nests in Wisconsin, so far as they go, substantiated Stoddard's findings.

Like the bob-white, the introduced ring-necked pheasant (*Phasianus colchicus torquatus*) is capable of repeated renesting attempts during the breeding season if previous efforts to bring off a brood have failed. It, too, appears to be a typically one-brood-per-season bird, though the evidence on this point is not conclusive. We have a record of one pheasant brood hatched about April 30, 1933, and it may be possible that a hen hatching out a brood as early as this may still have time, ability, and inclination to bring off a second brood by mid-summer. Even early young, however, are seldom hatched before the latter part of May in Iowa pheasant range and these are commonly seen in regular company with adults as late as August, when the laying season is essentially over.

Hamerstrom (1936) has published upon certain aspects of the data obtained from the 503 pheasant nests that were under observation in northwest Iowa during the seasons of 1933, 1934, and 1935. The basic data have been recast for use in the present paper, but the reader interested in a *résumé* of nesting information and statistics should consult the original publication.

Summarized Data on Pheasant Nests

The season of 1933 was what might be called "normal"; that of 1934 was one of severe drouth; and that of 1935 was unusually wet. Whether or not the

[1] Journal Paper No. J452 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 329.

Data providing the basis for this paper were obtained in connection with the cooperative research program of Iowa State College and Iowa Fish and Game Commission, 1932–1935, with the aid of financial contributions from J. N. ("Ding") Darling.

use of the data from the three seasons collectively will give us a typical picture we cannot say. Lumping the data in this manner at least gives us the advantage of a larger number of samples from which to draw conclusions than would be possible if the data were to be discussed according to single seasons.

The three columns on the left hand of Table 1 present the data on the pro-

portion of hatched (or partially hatched) clutches to those that were completely unsuccessful of the 251 nests for which the dates of laying of first eggs were established with fair definiteness. The 61.8% of nesting failures recorded for these is lower than the 76.9% calculated for the total of 445 nests under regular observation (Hamerstrom, 1936), but, since the data for the 251 nests are more complete as to details, the lower percentage of loss may conceivably be more representative also.

The next step in the evaluation of the success and failure data is the correction of the figures to exclude those nests the failure of which actually resulted in little or no loss at all, namely those clutches barely begun before loss or abandonment. The majority of these were of single abandoned eggs—sometimes merely "dropped eggs"—included in the data for completeness, but which obviously had scant influence on the course of reproduction. For the corrected data as presented in the three columns on the right hand of Table 1, the nesting failures amounted to 59.0%.

TABLE 1

RATIOS OF LOSS TO PARTIAL SUCCESS OF PHEASANT CLUTCHES FOR WHICH THE TIME OF LAYING OF FIRST EGG WAS ASCERTAINED

Clutches began	Complete data			Corrected data (see text)		
	Number clutches	Successful clutches	Failed clutches	Number clutches	Successful clutches	Failed clutches
First half of April	19	2	17	19	2 (10.5%)	17 (89.5%)
Second half of April	34	10	24	32	10 (31.3)%	22 (68.7%)
First half of May	52	22	30	52	22 (42.3%)	30 (57.7%)
Second half of May	60	26	34	54	26 (48.1%)	28 (51.9%)
First half of June	47	21	26	42	21 (50.0%)	21 (50.0%)
Second half of June	22	10	12	21	10 (47.6%)	11 (52.4%)
First half of July	14	4	10	11	4 (36.4%)	7 (63.6%)
Second half of July	2	0	2	2	0 (0.0%)	2 (100.0%)
August	0					
First half of Sept.	1	1	0	1	1 (100.0%)	0 (0.0%)
Total Clutches	251	96 (38.2%)	155 (61.8%)	234	96 (41.0%)	138 (59.0%)

Of the total of 503 pheasant nests, the date of laying of the first egg could be computed for 126 complete clutches with accuracy enough to assign them to the half-month periods. As the two columns on the left hand of Table 2 illustrate, the decrease in size of complete clutches is progressive with the advance of the season until late summer, when the number of samples becomes too low to have significance. of laying of the first eggs were determined. These calculations are subject to error from undetected losses of individual eggs between time of laying and hatching (Hamerstrom, 1936), but in the aggregate losses of this sort do not seem to be of much consequence, considerable though they may be for certain nests. Young that die shortly after hatching to be removed by scavengers before the visit of the observer

TABLE 2

SIZE OF COMPLETE PHEASANT CLUTCHES AND NUMBER OF YOUNG HATCHED PER SUCCESSFUL NEST

Clutches began	Data on 126 complete clutches		Data on number of young hatched from 91 successful clutches		
	Number complete clutches	Average eggs per clutch	Number successful clutches	Number of total eggs hatched	Average young per clutch
First half of April	9	19.4	2	26 of 46 or 56.5%	13.0
Second half of April	9	13.7	10	90 of 125 or 72.0%	9.0
First half of May	32	13.3	21	222 of 270 or 82.2%	10.6
Second half of May	28	10.6	25	228 of 265 or 86.0%	9.1
First half of June	23	9.2	19	124 of 173 or 71.7%	6.5
Second half of June	16	7.9	10	67 of 88 or 76.1%	6.7
First half of July	7	9.0	3	24 of 25 or 96.0%	8.0
Second half of July	1	8.0	0		
August	0		0		
First half of Sept.	1	8.0	1	8 of 8 or 100%	8.0

While evidence of irregularities such as those caused by more than one female contributing to a clutch were now and then encountered during the field studies, it is believed that most of the data on size of clutches are reliable.

The three columns on the right hand of Table 2 present the data on productivity in young of 91 successful nests for which the approximate dates and young that hatch and die undiscovered after the departure of the hen with the rest of the brood doubtless are a small source of additional error.

Up to date, we have devised no satisfactory method of keeping track of the reproductive performances of individual hen pheasants in the wild. Feather marking bears promise, provided that obstacles of technique may

TABLE 3

POSSIBLE TIME OF RENESTING OF PHEASANT HENS AFTER PREVIOUS FAILURES, ESTIMATED ON BASIS OF ADVANCEMENT OF CLUTCHES WHEN FAILURES OCCURRED. (Data Corrected as in Table 1)

Period in which failed clutch was begun	Number clutches failing	Number failures terminating breeding efforts, chiefly through hen mortality or serious injury	Number of failed clutches for which renesting attempts might subsequently be made and period of possible renesting								
			Second half April	First half May	Second half May	First half June	Second half June	First half July	Second half July	First half Aug.
First half of April	17 of 19	0	1 5.9%	8 47.1%	6 35.3%	2 11.8%				
Second half of April	22 of 32	0		12 54.5%	5 22.7%	4 18.2%	1 4.5%			
First half of May	30 of 52	1 3.3%			13 43.3%	9 30.0%	3 10.0%	4 13.3%		
Second half of May	28 of 54	5 17.9%				15 53.6%	3 10.7%	4 14.3%	1 3.6%	
First half of June	21 of 42	2 9.5%					12 57.1%	4 19.0%	3 14.3%	
Second half of June	11 of 21	1 9.1%						3 27.3%	2 18.2%	5 45.5%
First half of July	7 of 11	2 28.6%							1 14.3%	4 57.1%
Second half of July	2 of 2	0								2 100.0%

be overcome. Common experience on game farms and field evidence both indicate, however, that the loss of an incomplete clutch—especially early in the breeding season—may mean little or no delay in the starting of another clutch. If, on the other hand, a clutch is lost in an advanced stage of incubation, the succeeding clutch will probably not be begun for some time.

We have been unable to find in the literature references to the rate of resorption of pheasant ova after the cessation of laying and the beginning of incubation, nor the rate of development of the ova in the event of renesting of the hen following a material break in the laying period. As concerns the domestic hen (*Gallus*), Stieve (1918) determined that the most rapid resorption took place in the first five days, and Riddle (1911) that "The time interval between the beginning of rapid growth of the 6 mm. egg, and the breaking of the egg from the ovarian follicle (ovulation) is normally between five and eight days. In most cases it is either six or seven days." The amount of time required for the hen to resume laying is also conditioned by the degree to which her physical reserve has been depleted by incubation efforts.

In Table 3 are listed the periods in which hens having failed in earlier reproductive attempts may, with some reason, be expected to renest. The calculations were based upon the relative advancement of unsuccessful clutches at the time of failure and upon well-considered guesses as to the probable physical condition of the respective hens. The fact that these calculations serve as well as they do in linking the nesting success data with the data from broods observed in the field (right hand column, Table 4) is evidence that we have not gotten far away from the actual truth.

One unanswerable but significant question that continues to arise relates to the proportion of unsuccessful nests

TABLE 4

ESTIMATED TIME OF BEGINNING OF CLUTCHES FOR SUCCESSFUL NESTS AND FOR PHEASANT BROODS OBSERVED

Clutches began	Successful nests under observation	Broods observed in the field[a]
Second half of March	0 or 0.0%	1 or 0.4%
First half of April	2 or 2.1%	6 or 2.3%
Second half of April	10 or 10.4%	54 or 20.8%
First half of May	22 or 22.9%	86 or 33.1%
Second half of May	26 or 27.1%	53 or 20.4%
First half of June	21 or 21.9%	54 or 20.8%
Second half of June	10 or 10.4%	4 or 1.5%
First half of July	4 or 4.2%	2 or 0.8%
Second half of July and month of August	0 or 0.0%	0 or 0.0%
First half of Sept.	1 or 1.0%	0 or 0.0%
Total	96 or 100.0%	260 or 100.1%

[a] In the equations which follow, 7(1+6 or 0.4%+2.3% of 260) equals 2.8% of the 254 or *N* broods produced from clutches begun up to the middle of June; 54 equals 21.3%; 86, 33.9%; 53, 20.9%.

representing mortality of the pheasant hens. Mortality or waste of the reproductive efforts of individual hens (as through incubation of unhatchable eggs for most of the summer), when known to have occurred, is indicated in one of the columns of Table 3; but it is a certainty that some mortality escaped detection.

Mortality, or injury probably severe enough to terminate reproduction for the season, was, in most observed instances, due to the striking of hens by mowing machines. The loss of adults recorded during the breeding season from natural enemies other than great horned owls (*Bubo virginianus*) and red foxes (*Vulpes fulva*) was inconsequential. Although pheasants at times were strongly represented in the diets of horned owl (Errington, et al., unpublished) and fox (Errington, 1935; 1937), the heaviest pressure was commonly borne by pheasant populations of such high density that the net effect upon reproduction may not have been great.

Periods at Which Hens Begin to Lay

The data on time of beginning of clutches from which broods were hatched were derived from notes taken on the size of young pheasants of broods seen chiefly during the seasons of 1933 and 1934. Brood data were obtained not only from the localities where intensive nesting studies were carried on, but deputy game wardens, notably John F. Holst Jr., in 1934, also supplied valuable data from northwest Iowa as a whole.

The use of the brood data of Table 4 in conjunction with the nesting data of Tables 1 and 3 is of primary importance in giving us a basis for calculating the relative proportions of hens that begin to lay in each of the semi-monthly periods. The authors are particularly indebted to Dr. A. E. Brandt, of the Statistical Laboratory, Iowa State College, for help received in the mathematical interpretation of these data.

Let N equal the 254 broods produced from clutches begun up to the middle of June, after which there is practically no reason to suspect that more hens are laying for the first time during the season.

Then, let a equal the number of hens beginning to lay prior to the middle of April; b in the second half of April; c in the first half of May; d in the second half of May; e in the first half of June.

From the tabulated data certain values may be established:

$$.105a = .028N$$

$$.313\left(b+\frac{a}{19}\right) = .213N$$

$$.423\left(c+\frac{12b}{32}+\frac{8a}{19}\right) = .339N$$

$$.481\left(d+\frac{13c}{52}+\frac{5b}{32}+\frac{6a}{19}\right) = .209N$$

$$.500\left(e+\frac{15d}{54}+\frac{9c}{42}+\frac{4b}{32}+\frac{2a}{19}\right) = .213N$$

Solving for the various unknowns we find:

$$a = .267\,N$$

$$b = \frac{.213\,N - .004\,N}{.313} = .668\,N$$

$$c = \frac{.339\,N - .106\,N - .048\,N}{.423} = .437\,N$$

$$d = \frac{.209\,N - .053\,N - .050\,N - .041\,N}{.481} = .135\,N$$

$$e = \frac{.213\,N - .019\,N - .038\,N - .042\,N - .014\,N}{.500} = .200\,N$$

For a, b, and c, the values are about what one might expect, but experience gives us no cause to believe that the value of e is actually greater than that of d. Indeed, it is our belief that in the wild there would be virtually no hens nesting for the first time as late as June.

If we attribute to sampling or other error the unexpected value found for e and assume that e actually has a value close to zero, we may combine the data for the second half of May and the first half of June and solve again for d:

$$.481\left(d + \frac{13c}{52} + \frac{5b}{32} + \frac{6a}{19}\right) + .500\left(\frac{15d}{54} + \frac{9c}{52} + \frac{4b}{32} + \frac{2a}{19}\right) = .422\,N$$

$$d = \frac{.422\,N - .053\,N - .050\,N - .041\,N - .038\,N - .042\,N - .014\,N}{.620} = .297\,N$$

These values of a, b, c, and d may be expressed in percentages of the total breeding hen population as follows:

$a = .267\ N = 16.0\%$ of hens beginning to nest prior to the middle of April;

$b = .668\ N = 40.0\%$, in the second half of April;

$c = .437\ N = 26.2\%$, in the first half of May;

$d = .297\ N = 17.8\%$, in the second half of May.

Evaluation of Pheasant Nesting Losses

In trying to arrive at a closer evaluation of pheasant nesting losses, it was found advantageous to use, with necessary modifications, the procedure described by Errington (1933) in his paper on the nesting of the bob-white in Wisconsin.

Let us say that we are dealing with a sample population of 100 pheasant hens, typical in every way of the northern Iowa wild populations. A small percentage of these hens will certainly squander their incubation efforts upon infertile or addled clutches, but, in the absence of data to the contrary, we shall have to assume that practically all or a very large proportion of the hens will at least lay eggs, unless suffering from injuries or poor health. Examina-

TABLE 5

CALCULATED PRODUCTIVITY OF A HYPOTHETICAL 100 PHEASANT HEN SAMPLE, ON BASIS OF DATA PRESENTED IN TABLES 1 TO 4

Period during which clutches were begun	Calculated number of hens laying (see text for number of hens laying for first time)	Number of clutches successful	Number of newly hatched young	Hens retired from further nesting by success of efforts	Hens beginning unsuccessful nests in period	Hens killed or eliminated from further nesting by continued incubation of infertile clutches, etc.	Hens in condition to resume laying and estimated period in which renesting should take place
Prior to middle of April	16.00 hens laying for first time	16.0×10.5% =1.68	1.68×13.0 =21.84	1.68	16.0×89.5% =14.32	0.0	14.32×5.9%=0.84 by second half of April 14.32×47.1%=6.74 by first half of May 14.32×35.3%=5.05 by second half of May 14.32×11.8%=1.69 by first half of June
Second half of April	40.00 hens laying for first time +0.84 from first half of April =40.84	40.84×31.3% =12.78	12.78×9.0 =115.02	12.78	40.84×68.7% =28.06	0.0	28.06×54.5%=15.29 by first half of May 28.06×22.7%=6.37 by second half of May 28.06×18.2%=5.11 by first half of June 28.06×4.5%=1.26 by second half of June
First half of May	26.2 hens laying for first time +6.74 from first half of April +15.29 from second half of April=48.23	48.23×42.3% =20.4	20.4×10.6 =216.24	20.40	48.23×57.7% =27.83	27.83×3.33% =0.93	27.83×43.3%=12.05 by second half of May 27.83×30.0%=8.35 by first half of June 27.83×10.0%=2.78 by second half of June 27.83×13.3%=3.70 by first half of July
Second half of May	17.8 hens laying for first time +5.05 from first half of April +6.37 from second half of April +12.05 from first half of May =41.27	41.27×48.1% =19.85	19.85×9.1 =180.64	19.85	41.27×51.9% =21.42	21.42×17.9% =3.83	21.42×53.6%=11.48 by first half of June 21.42×10.7%=2.29 by second half of June 21.42×14.3%=3.06 by first half of July 21.42×3.6%=0.77 by second half of July

TABLE 5 (*Continued*)

TABLE 5 (*Continued*)

First half of June	No hens laying for first time. 1.69 from first half of April +5.11 from second half of April +8.35 from first half of May +11.48 from second half of May =26.63	26.63×50.0% =13.315	13.315×6.5 =86.55	13.315	26.63×50.0% =13.315	13.315×9.5% =1.26	13.315×57.1%=7.60 by second half of June 13.315×19.0%=2.53 by first half of July 13.315×14.3%=1.90 by second half of July
Second half of June	No hens laying for first time. 1.26 from second half of April +2.78 from first half of May +2.29 from second half of May +7.60 from first half of June =13.93	13.93×47.6% =6.63	6.63×6.7 =44.42	6.63	13.93×52.4% =7.3	7.3×9.1% =0.66	7.3×27.3%=1.99 by first half of July 7.3×18.2%=1.33 by second half of July 7.3×45.5%=3.32 by first half of Aug., if at all
First half of July	3.70 from first half of May +3.06 from second half of May +2.53 from first half of June +1.99 from second half of June =11.28	11.28×36.4% =4.11	4.11×8.0 =32.88	4.11	11.28×63.6% =7.17	7.17×28.6% =2.05	7.17×14.3%=1.03 by second half of July 7.17×57.1%=4.09 by first half of Aug., if at all
Second half of July	0.77 from second half of May +1.90 from first half of June +1.33 from second half of June +1.03 from first half of July =5.03	0.0	0.0	0.0	5.03	0.0	5.03 by first half of Aug., if at all

tion of specimens collected at random or found killed by traffic on the highways during the breeding season has so far brought to light no abnormalities that appeared to prevent reproductive endeavor.

Granted that critical analyses of nesting losses may as yet be little more than preliminary gropings, we may from a relatively simple framework of facts construct something of a coherent picture, such as that presented in Table 5.

Table 5, of course, reflects maximum productivity consistent with the data in hand. Its weaknesses lie in possibly atypical values for the smaller samples, in lack of knowledge concerning undetected mortality of hens, and in the uncertainty that unsuccessful hens did renest in the periods for which renesting was designated. Nevertheless, we have strong brood data to check against the nesting data for a large part of the season, and the resulting picture up to the middle of June can hardly be far from correct.

The recording of only 6 broods in the field from clutches begun in the second half of June and the first half of July provides some evidence that midsummer renesting takes place on a lesser scale than as calculated in Table 5. August being plainly too late in the season for general renesting (we have no records at all of pheasant clutches begun in this month), it is to be expected that July should be sufficiently near the borderline to cause individual birds to discontinue their breeding efforts.

On the basis of the brood data we may make an attempt to correct the productivity calculations for the season subsequent to the middle of June. The right hand column of Table 6 credits 4 and 2 broods of 260 or 1.54% and 0.77% to clutches begun in the second half of June and the first half of July, respectively. According to the calculations of Table 5, 8.42% and 5.22% of the total number of broods may be credited to these respective periods. While it is true that any broods hatched so late in the season would stand a greater chance of being overlooked in the course of the field studies because of difficulty in obtaining data on the smaller sizes of young pheasants, we feel that the truth probably lies somewhere between the extremes indicated by the figures for the later breeding periods.

A total of 68.03 hens are successful in bringing off broods from clutches begun up to the middle of June, and the broods for this part of the season represent 97.69% of those observed in the wild. This would leave 2.31% of the broods to hatch from clutches begun after the middle of June and would represent success for 1.61 additional hens. Of the 1.61 hens successfully bringing off broods from clutches begun after the middle of June, two-thirds would be second half of June hens and one-third first half of July hens (Table 4), or 1.073 and 0.537, respectively. Together, these hens would produce 11.49 young, at the rates given in Table 2. The calculations on productivity are summarized in Table 6, and from these we may see that the percentage of hens successfully bringing off broods is probably somewhere between 69.64% and 78.77% and that the total number of newly hatched young representing the productivity of the hypothetical sample of 100 hens should be between 631.78 and 697.59.

TABLE 6

SUMMARIZED CALCULATIONS ON THE PRODUCTIVITY OF A HYPOTHETICAL 100 PHEASANT HEN SAMPLE, ON BASIS OF DATA PRESENTED IN TABLES 1 TO 5

Basis of calculation	Number of hens bringing off broods	Number of hens failing to bring off broods	Unsuccessful hens		Total number of young brought off during nesting season
			Hens failing largely because of known mortality	Hens failing for unknown reasons, including end of nesting season	
Full season as in Table 5	78.77	21.17	8.73	12.44	697.59
Season up to middle of June as in Table 5; season after middle of June corrected on basis of brood data in Table 4 and calculations in text	68.03 up to middle of June +1.61 calc. for rest of season =69.64	30.36	?	?	620.29 up to middle of June+11.49 calculated for rest of season =631.78
Range of probable accuracy	69.64 to 78.77	21.17 to 30.36	?	?	631.78 to 697.59

A further check on these figures is supplied by field data gathered by Holst and others in the northern part of the state from July 23 to August 7, 1934. During this period of approximately two weeks, between the virtual termination of the nesting season and the main moulting season, the records show that 106 hen pheasants and 83 broods totalling 441 young were seen. Of the hens, 65 were with broods and 41 were without; and there were 18 broods seen without hens, of which 2 were attended by lone cocks (cocks may or may not be noted with hens accompanied by young). One of the 83 broods consisted of young of mixed sizes and others were doubtless made up of combinations of broods or only parts of broods; but, taken together, errors in one direction should compensate fairly well for errors in the other. The average size of the broods was 5.31 young at an average age of a little less than 6 weeks, or an average of 4.16 young for all hens seen at this time of the season.

Considered year by year, the primary destruction of nests by predators has shown little change except for slightly increased losses from small mammals, particularly ground squirrels (largely *Citellus franklini* and perhaps also *C. tridecemlineatus*). Table 7 shows that losses from crows (*Corvus brachyrhynchos*) have not differed greatly nor have the losses from miscellaneous and unknown predators collectively, although the composition of the general predator factor has shown visible variation from year to year.

If one considers together the known nesting losses from predation and the losses from unknown causes—which unquestionably include some losses from predation but which certainly may not all be attributed to predators—the resulting figures reveal less uniformity but even so do not refute the possibility of compensatory trends existing in the loss rates.

Compensatory trends are especially suggested by observations on secondary nest destruction by predators, following desertion of nests mowed over, burned over, and trampled by livestock. Regardless of the occasional exposed and abandoned clutch that may lie undisturbed for weeks and the alfalfa field clutches that may now and

TABLE 7

COMPARISON OF NESTING LOSSES FROM PREDATION AND UNKNOWN CAUSES INCLUDING PROBABLE PREDATION

Season	Total of nests under regular observation	Total known loss from predation	Losses from various predators					Unexplained losses doubtless including some from predation	Total losses from predation and unknown causes combined
			Crow	Ground Squirrel	Unidentified mammals	Misc. mammals	Unknown predators		
1933	44	6 13.6%	4 9.1%			1 2.3%	1 2.3%	2 4.5%	8 18.2%
1934	169	22 13.0%	10 5.9%		3 1.8%	1 0.6%	8 4.7%	23 13.6%	45 26.6%
1935	232	41 17.7%	14 6.0%	6 2.6%	6 2.6%	5 2.2%	10 4.3%	37 15.9%	78 33.6%
Total	445	69 15.5%	28 6.3%	6 1.3%	9 2.0%	7 1.6%	19 4.3%	62 13.9%	131 29.4%

then be successfully incubated after having been mowed over, it is commonly just a matter of days before some animal avails itself of the eggs in such nests. The usual egg eater to profit is the crow, but, if not this species, ground squirrels, skunks, dogs, or other creatures sooner or later find a large proportion of the eggs thus uncovered, perhaps partially broken or scattered, and otherwise rendered conspicuous.

Vulnerability of many nests is unquestionably associated with lack of ground cover, but we must admit that there is much about this that we do not understand. The drouth season of 1934 was accompanied by the poorest general cover conditions we have observed but not by any corresponding increase of nest failures (Hamerstrom, 1936). Neither did we find any significant differences in the percentage of success for nests placed in what was judged to be good cover or poor (Hamerstrom, 1936). On the other hand, Bennett (1935) found in his studies of the blue-winged teal (*Querquedula discors*) in the same area a decided connection between nesting success and quality of the cover.

JUVENILE MORTALITY AS INDICATED BY FIELD DATA

That young pheasants suffer a certain amount of loss from predation, mowing, motor traffic, storm, and other mortality factors has been well borne out by investigation. Of these factors, we have paid particular attention to predation, with a view toward evaluating its significance from the standpoint of population.

Contemporaneous studies of the food habits of various predatory species in

our northwest Iowa observational areas have shown the heaviest pressure on young pheasants to be exerted by the marsh hawk (*Circus hudsonius*). Our food habits data on horned owls and red foxes are limited for the time of the season when large numbers of young pheasants are abroad, but the data which we have suggest rather light pressure except for an occasional locality. Toward fall, the red-tailed hawk (*Buteo borealis*) is seen now and then feeding on nearly grown young; but the difficulties here of differentiating between prey killed by the hawk and carcasses of highway victims are considerable.

Our data on the marsh hawk are most comprehensive, and we may copy from a recent publication (Errington and Breckenridge, 1936). A total of 346 gullet collections from tethered young marsh hawks (for a discussion of technique, see Errington, 1932) in the vicinity of Ruthven, Iowa, during the summers of 1933–35 revealed 577 items of vertebrate prey. Of the 577 items, 24 or 4.31% were young pheasants ranging in size up to nearly grown. One was a chick of about 1 day; another was less than a week old; 1 was about 2 weeks; 1, about 3 weeks; 12, between 4 and 6 weeks; 3, about 7 weeks; 2, about 9 weeks; 2, about 10 weeks; and 1, about 12 weeks.

In attempting to evaluate the rather severe pressure of the marsh hawk upon young pheasants, it would be useful to compare the brood data from areas regularly hunted over by marsh hawks with data from areas in which the hawks were seldom seen during the summer. Our 1933 data permit us to make such a comparison in the vicinity of Ruthven. The favorite hunting grounds of the Ruthven marsh hawks were south and west of Barringer's Slough, and 10 brood counts from here averaged 6.2 young at an average age of about 6 weeks. Counts of 22 broods observed within a few miles but outside of the usual hunting radius of known marsh hawks averaged 5.1 young at an average age of about 8 weeks.

The number of samples given above is not as large as could be desired, and the data relate to different age classes of young. For all of that, however, the data from both sizes of young are in keeping with the data summarized in Table 8, which deals with apparently unmixed broods observed by the authors or cooperators during the entire investigation. In short, there seemed to be no perceptible relation between the conspicuous preying of the local marsh hawks and the seasonal shrinkage in size of pheasant broods.

It may be noted from Table 8 that, despite differences in number of young hatched from clutches begun in different periods, the average sizes of broods for given ages of young are remarkably similar. They are so similar, indeed, that we feel that the figures given in the totals for the age classes illustrate perfectly well the gradual decline in size of broods that characteristically takes place with the advancing of the season.

Toward the middle or the latter part of August, brood counts become of greatly decreased value, on the whole, because of the increased heterogeneity of composition of the pheasant groups to be seen. Groups of pheasants made up of 20 to 30 birds—including adults

of both sexes and young evidently from several broods—may be encountered at choice gathering spots, as at the edges of corn fields and marshes.

Autumn in northwest Iowa is normally a season of dense herbaceous vegetation, with ground cover almost everywhere except as cut or grazed down. Discoveries of evidence of mortality of young pheasants become less and less frequent except along highways, where unwary birds still come to sudden ends through the joint medium of motor traffic, raptorial enemies, and human poachers interested in "fries."

Although we do not have many direct data on pheasant population levels for the three seasons covered by this study, it is our impression that there was a slight decline from 1933 to 1935, attributed by us to over-shooting—an impression substantiated in some measure by our data on predation (Errington, 1937 and unpublished). Following the heavy losses of the winter of 1935–36 (Green and Beed, 1936), however, a marked decline in the breeding population was noted for the summer of 1936.

During the summer of 1936, Errington, incidental to other studies, observed a few broods (about a dozen, so far as they could be distinguished) in the vicinity of Ruthven. The counts obtained were consistently large, averaging 9 young at the age of a little less than 4 weeks (compare with the data presented in Table 8). There is considerable reason otherwise to believe that the 1936 broods of young pheasants were larger as a rule over much of northwest Iowa; and, if true, this possibly bears some relation to the decreased density of the general pheasant population.

We are fully aware of the dangers of comparing population phenomena of one species with those of another, but it may not be amiss to suggest that the recovery of pheasant populations during the breeding season may have certain features in common with the pic-

TABLE 8

SUMMARIZED DATA ON DECLINE OF SIZE OF BROODS WITH ADVANCEMENT OF THE SEASON

Month in which clutches producing broods were begun	Average number of young hatched (data from table 2)	Average number of young seen in broods of different age classes in the field			
		One to three weeks	Four to five weeks	Six to seven weeks	Eight to ten weeks and older
April	9.67 for 12 successful clutches			5.14 for 14 brood samples	4.4 for 42 brood samples
May	9.78 for 46 successful clutches	5.3 for 3 brood samples	5.96 for 48 brood samples	5.28 for 64 brood samples	6.18 for 17 brood samples
June	6.59 for 29 successful clutches	7.09 for 11 brood samples	5.89 for 45 brood samples		
Totals	8.7 for 87 successful clutches	6.71 for 14 brood samples	5.92 for 93 brood samples	5.26 for 78 brood samples	4.92 for 59 brood samples

ture partially worked out for the bob-white at Prairie du Sac, Wisconsin (Errington and Hamerstrom, 1936, Table 75, p. 422). For convenience of comparison, the population recovery curve for 8 bob-white breeding seasons at Prairie du Sac may be represented as in Figure 1. For both pheasants and bob-whites, and for a great many other species, we may apparently expect pro-

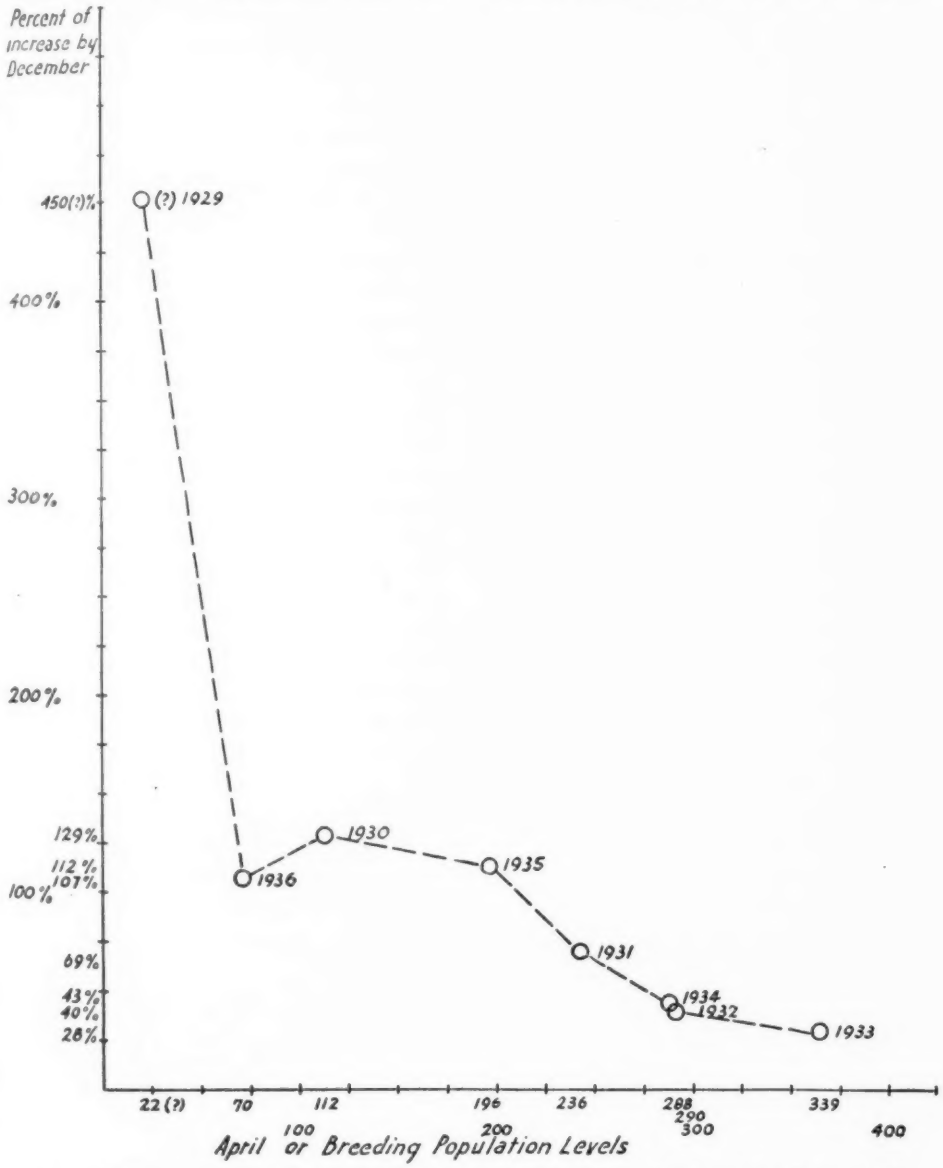

Fig. 1. Recovery rates of a bob-white quail population on five square miles east of Prairie du Sac, Wisconsin, for eight breeding seasons, 1929–1936.

gressively increasing juvenile mortality as a natural accompaniment of rising population densities, until a state of relative equilibrium may be reached.

Aside from the unknown roles played by shooting, accident, weather, disease, etc., the intensity of juvenile mortality of the ring-necked pheasant appears to be largely a matter of the immaturity and inexperience of the birds and their abundance in relation to the quality and extent of their habitable environment. So far as our data go, they suggest that under conditions bearing any semblance of stability, juvenile losses seem to go on at approximately the same rate, on a local as well as on a sub-regional scale, seemingly little influenced by ordinary variations in kinds and numbers of predators resident at the time.

SIGNIFICANCE OF FINDINGS FROM THE STANDPOINT OF MANAGEMENT

Readers interested in management, if they have followed closely the text and tables as far as this, may hardly escape concluding that we are still a long way from a clear understanding of the mechanisms governing population levels of the ring-necked pheasant in nature. The technical obstacles in the way of clear understanding are so great in many cases that about the best we can do for the present is simply to recognize the existing facts without straining too hard to explain them.

The picture that we have pieced together, at the least, casts doubts upon the effectiveness of some of the management measures currently in use to increase the numbers of pheasants for sporting or other purposes.

The postulated advantage of having the earliest clutches produce most of the broods is not substantiated by the data as well as might have been expected. There is, to be sure, a disadvantage in having many broods brought off very late in the season, but clutches begun after the middle of June stand little chance of producing young anyway (Table 4). Broods hatched from June clutches have time in which to make their growth either before winter or before the November shooting season, and, for corresponding age classes, they compare favorably with broods from clutches begun earlier (Table 8).

Furthermore, the evidence that a strong majority of the hens, by virtue of renestings, succeed in bringing off normally satisfactory broods (Tables 5 and 6) in spite of heavy nesting losses (Table 1 and Hamerstrom, 1936) suggests a reproductive resilience on the part of the pheasant that enables it to sustain in established range just about whatever breeding setbacks it may ordinarily need to. Careless nester that it often is, its net annual productivity of young is high among wild creatures of similar type and habitat requirements and shows certain elements of constancy that seem within limits observed to be unaffected by differences in status of many of the agencies to which losses may be charged, including the usual types and densities of predators upon eggs and young found in northwest Iowa.

It is entirely conceivable, however, that acute local situations may arise and call for repression of some nesting enemy or other. Stoddard's (1931; 1934) experiences with fire ants (*Solenopsis geminata*) on bob-white nesting grounds in southeastern United States provide a case in point; but we have

seen nothing of like nature and magnitude during our pheasant studies.

The use of flushing devices in alfalfa and hay fields appears to be of value principally in preventing birds from being struck by the mower sickle.

Manipulation of nesting cover as a management measure in good pheasant range seems to have the greatest potentialities for desired population increases if stress is laid upon the creation of new habitats in pheasant-vacant spaces rather than upon improvement of nesting grounds already fairly suitable. It is not necessarily of supreme importance to insure that a given pheasant hen bring off her season's brood from her first clutch of eggs, when any time within the next couple of months may serve as well; but it may be wise to see to it that there are plenty of places over the landscape where resident birds may station themselves with a minimum of crowding if they so wish. The exclusion of livestock from odd corners, unused section lines, the banks of drainage ditches, etc., and more judicious control of burning may mean the essential difference between reasonably good management and mere futile tinkering with biological mechanisms of which we know very little.

SUMMARY

The ring-necked pheasant hen typically brings off one brood of young per season if it can. Its chief laying season extends from the middle of April to the middle of June in northwest Iowa, and during this time the vast majority of the clutches destined to produce young will be begun. Clutches begun prior to the middle of April or subsequent to the middle of June appear to be of little consequence in reproduction.

Observed nesting losses have been high but appear to have been largely offset by successful renesting attempts following the failure of earlier clutches. Of a total of 445 nests under regular observation from 1933 to 1935, 76.9% were unsuccessful. Of 251 nests for which the approximate dates of laying of first eggs were ascertained, 61.8% were failures. Correcting the data by dropping from further consideration 17 clutches (mostly of single eggs) that had been barely started before failure occurred and which for practical purposes had slight if any actual significance, we still have a failure of 59.0% of the 234 clutches for which time of beginning is known.

Nesting losses established at from 59.0% to 76.9% of the clutches look very alarming if viewed uncritically. However, calculations on the basis of the data at hand indicate that, in round numbers, from 70% to 80% of the hens finally succeed in bringing off broods. The data most pertinent to such calculations are those providing ratios of successful to unsuccessful clutches begun in half-month intervals during the breeding season, those showing relative advancement of incubation of failed clutches, and those showing the proportion of broods seen in the field that were hatched from clutches begun during the various periods.

Success or failure of clutches seemed to bear less evident relation to appraised quality of nesting cover than might have been expected; nor has there seemed to be any clear connection between differences in kinds and numbers of nesting enemies and the intensity of depredations upon eggs as manifested from year to year, thus confirming others of our studies.

Brood count data indicate a gradual decline in average size of broods that bears a rather distinct relation to the age of the young but not to the time of the season at which the young were hatched. It appears broadly true that broods brought off at any time during the main nesting season are comparable in size for comparable age classes and enjoy not dissimilar advantages. The limited data we have do not reveal a more rapid decline in average size of broods known to have been subjected to the heaviest predation of which we have record. There are some indications that the survival of young is greater in environments somewhat understocked with the species.

In view of the increasing likelihood that many of the interrelationships between breeding pheasants, their existing habitats, and the usual predators upon their eggs and young, are naturally stable and self-adjusting, and in view of the paucity of our knowledge, management suggestions could well be made with caution. Increasing the extent rather than the quality of nesting habitats in established pheasant range has about as much promise as anything we can see as a general management measure.

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WORM PARASITES IN THEIR RELATIONS TO WILDLIFE INVESTIGATIONS[1]

Harley J. Van Cleave

Relatively little is known of the parasites of animals in nature and our knowledge is particularly incomplete regarding the effects of all but a few of the worms infesting wild animals of all kinds. It is a well-known fact that few individual animals of any species are wholly free from worm parasites. Some parasites are known to produce abnormal conditions in the sheltering host animal though many others have never yet been linked with any diseased condition in the host.

Every animal in nature from the smallest and least important minnow to the largest mammal may be host to a varied assortment of parasitic worms. These unbidden guests have been so successful in their attempt at gaining a livelihood at the expense of some other animal that there are few submarginal zones of the animal body which some sort of worm will not attempt to colonize. While the digestive tract is popularly believed to be the chief seat of parasitic invasion, the lungs, heart, blood vessels, liver, kidneys, eyes, brain, muscles and other kinds of tissues are capable of supporting some kinds of worms in some stages of their development.

The investigations of worm parasites have, in the past, centered around the studies on parasites of man and his domestic animals. To be sure, there have been many papers recording the presence of parasitic worms in wild animals but on the whole these have been primarily taxonomic and morphologic, viewing the worms from the point of view of science rather than from that of the animal which acts as host. In fact there are three points of view from which parasite studies should be considered: that of the host, that of the parasite and that of the habitat or environment. The three aspects are so intimately related that recent studies are often cited as studies in host-parasite-habitat interrelationships. Such an ecological viewpoint is forcing new fields for investigation upon the attention of conservationists and parasitologists, and demanding that conservationists should know more about the worms which attack our wild animals, their influence as causes of disease and death, and how outbreaks may be avoided or held in check. Conversely, there is a parallel demand that students of worms should pay more attention to the biological effects of worms on their hosts and to the ecological problems of interrelations of worms, hosts, and habitats rather than to the static aspects of classification and structure alone.

In the realm of human parasitology and in the study of parasites of domestic animals, there is a great deal of information available regarding the relations of worm parasites to disease and as causes of death. For a considerable number of internal parasites of man and the domestic animals, routine treatments for the removal of parasites have been perfected. Of still greater significance is the fact that measures and

[1] Contributions from the Zoological Laboratory of the University of Illinois, No. 506.

practices are available for prevention of dangerous outbreaks of parasitic worms among humans and their domestic animals. The so-called McLean County system of swine sanitation developed by the Department of Agriculture is a striking example of the possibility of geniune control of worm parasites. Where routine practice of recommended procedure can be carried out, the loss of hogs due to Ascaris infestation is completely eliminated. In time most other dangerous worm parasites will probably be effectively held in check by following appropriate procedures. How long it will be before similar control measures against some of the parasites of wildlife may become effective depends on how actively a research program is pushed. Ignorance, carelessness, and inability to put known control measures into effect are the chief causes of costly outbreaks of parasitic infestations among human beings and their dependent animals. The same three obstacles confront the students of parasites in their relations to wildlife, but the greatest of these is ignorance.

In game and fish management and propagation there are four chief directions in which we must look to secure a better understanding of the relations of worm parasites to wildlife investigations: (1) the lack of knowledge concerning the normal health of animals; (2) lack of information as to the species of parasites infesting each species of wild animal and the life histories of the various worms; (3) lack of conclusive evidence as to the responsibility of known worms for observed pathological conditions; and (4) lack of knowledge as to what is to be done if all the foregoing obstacles are overcome.

In any investigation attempting to evaluate the effects of parasites or any other factor operating on the body of an animal, the first requisite is a knowledge of the animal under normal conditions. Such information is readily available for man and the domestic animals but even here the desirable information is far from complete. Our whole practice of medicine and concept of physiology has, in the past, been based on general averages. We are now beginning to learn that many individuals depart from the average without being abnormal.

Diagnosis of diseased conditions due to parasitic worms is never safely set at the time when the individual shows marked symptoms. Frequently this is too late for saving the individual though often it may be in time to serve as a warning to take measures toward preventing further loss. Nowhere does the trite slogan about the ounce of prevention have more meaning than in the field of preventive measures leveled against the ravages of parasitic worms.

Failure to recognize early stages of worm infestations are often encountered in veterinary zoology. For instance, practically every horse carries a quota of internal parasites. A horse apparently in good condition may have as many as a thousand worms living in its digestive tract. The fact that a somewhat heavier infestation leads to evident decline makes one wonder if the apparently healthy animal may not be distinctly below prime condition when carrying even a relatively small number of parasites. The

indifferent attitude expressed in David Harum's homely belief that it is a good thing for a dog to have a few fleas since it keeps him from forgetting he is a dog is a common attitude toward internal parasites as well. Just as long as people looked upon worms as the will of God and upon their unknown methods of origin as supernatural, there was no hope of progress in treatment of either man or other animals. Likewise under these mediaeval attitudes prevention and avoidance were wholly impossible. In this age of science, recognition of the presence of parasites in any economically valuable kind of animal is a challenge to investigate possible methods of relief and programs of prevention.

In dealing with game animals and fishes, which are not in close confinement as are the domestic animals, the best measures to follow are those looking toward the avoidance of losses by prevention of infestation. Wherever possible, individuals giving evidence of abnormal conditions should be isolated from others or even destroyed if the condition is acute. In all such instances as much detailed information as possible should be recorded for future study and worms apparently causing the trouble should be carefully preserved for study and identification.

Two other practices are to be recommended. In the first place, microscopic examinations of droppings will commonly give fair evidence of the degree of infestation by parasitic worms of the digestive tract, and to the observer with some experience, the worms may be identified by the form, size and appearance of the eggs. The second recommended practice is one adapted from the field of veterinary science. If worms are found to be increasing in numbers, the source of the trouble should be sought. Possible foci for contamination by domestic animals should be investigated and conditions under which the animals are living should be studied thoroughly. Very commonly dogs or other carnivores are important agents in maintaining heavy infestations of larval tapeworms in ruminants. Swampy or moist pastures offer conditions for excessive breeding of parasitic worms. Flukes thrive there because snails essential to their cyclic development are present. Nematodes likewise prosper because their eggs are given ample opportunity for development on the moist soil. Drainage of low lands used for range, or fencing off of especially hazardous areas, are types of control recommended. Promiscuous destruction of life by treating ponds and streams with chemicals to destroy snails is rarely to be recommended.

In outlining any program of study for parasitic worms in their relations to wildlife investigations, the knowledge gained from human and veterinary parasitology must be on call continuously. Many different kinds of worm parasites are not particular as to their choice of an animal in which to live. Consequently game animals often may become incidental or accidental hosts of species usually found in other forms of life. For instance most persons think of rats, hogs, and man as essentially a closed circuit for the developmental cycle of the round worms popularly known as trichina but these are merely a few from an extended list

of animals capable of harboring *Trichinella spiralis*. Many game and wild animals are included among the potential hosts and therefore have significance in the possible spread of trichinosis. Likewise the fish tapeworm of man (*Diphyllobothrium latum*) which he secures by eating raw or improperly cooked fish, may also live in the intestine of dogs, bears, and other fish-eating mammals. There is mutual danger to both man and other hosts of this tapeworm arising from close association.

A lung fluke (*Paragonimus kellicotti*) known for many years as an occasional parasite in the lungs of cats, dogs, and pigs, has recently been found to be a normal parasite in the lungs of the mink. This exemplifies a condition which has not been uncommon in studies of worm parasites. Species long considered as rare may have been discovered in only accidental hosts but prove to be fairly common when the true host is discovered. While many species of worms have one or a few normal hosts in which the parasite prospers, they may occur in other hosts that play a minor role so far as numbers of parasites are concerned but rank as important agents in dissemination of the parasites. In Europe, for example, the starling has been found carrying the gapeworm of poultry and thus may be an important agent in the spread of gapes to uninfested flocks of fowls.

Particularly in parks and sanctuaries the animals which man seeks to protect are often reduced to a state closely approaching domestication. At least in some instances there are dangers to man, to his domestic animals, and to the protected wildlife accruing from associations which facilitate exchange of parasites. The most unfortunate aspect of this exchange is the fact that in new victims parasites may produce more serious pathological conditions than in their usual hosts. There are many very interesting aspects of immunity and resistance to infestation by metazoan parasites awaiting solution and students interested in parasites of wild animals can help in the solution of these problems.

In agricultural practice it has long been recognized that continuous use of range or feeding lots for the same kind of animals tends to pile up worm infestations. Dr. M. C. Hall, one of the most widely recognized American authorities on animal parasites is responsible for the slogan, "Permanent pastures perpetuate parasites." Unless ample space for natural choice of range and feeding ground is given to game animals, this slogan no doubt will be fully as applicable to crowded sanctuaries as to farm pastures.

The dangers of exchange of parasitic worms between protected and domestic animals mentioned earlier in this paper are not imaginary or fanciful. Cattle have doubtless acquired the large liver fluke (*Fascioloides magna*) from native deer. Lung worms, kidney worms, tapeworms, liver flukes, and thorny-headed worms are but a few of the groups of worm parasites which pass readily from domestic to wild animals and *vice versa*, with chances for pyramiding of infestations under artificial limitations of range.

Particularly does the practice of shipping game birds and mammals to different parts of the country and the

importation of species from other countries open avenues for dangerous spread of parasitic worms. Wherever possible eggs of fishes and of birds should be employed for introducing species into new localities as being devoid of the dangers accompanying transportation of mature animals, since none of the worm parasites are transported in eggs. Quarantine measures more effective than those now in use against parasitic worms should be put into operation in the interests of conservation of wild as well as of domestic animals.

The damage done by worm parasites is not to be accurately measured solely by the number of animals killed. Many sorts of parasites operate in a less spectacular, but nevertheless destructive, manner. Thus sterility is produced in otherwise apparently healthy bass by presence of tapeworm larvae in the gonads and body cavity. Hookworms in man are known to retard or inhibit reproductive functions. Numerous wild animals harbor hookworms but the physiological effects have not been studied. Certain trematodes in the genital organs of hens are known to materially decrease egg production but the effects of flukes in wild birds have not been determined.

All game animals, from fishes to large game mammals, harbor internal worms. The nature of the damage done by these parasites is highly variable and for many of them only imperfectly understood. One of the commonest charges against intestinal parasites is that they utilize foods elaborated for support and growth of the host animal. But this loss is seemingly less important than the harm done by most worms in producing toxins which poison the host. There are other types of damage of which various sorts of mechanical injury are illustrative. Thus tapeworms and some other parasites at times become so numerous as to block the intestine and in other organs serious derangements accompany the crowding due to their growth. Gid parasites in the brain and filarial worms in the heart are familiar examples. Often these mechanical effects are accompanied also by direct injury to the host tissues. Thus flukes in sheep and other ruminants destroy liver tissue by pinching off bits with the mouth. Very commonly flukes and roundworms are bright red in color, due to the presence of blood obtained from the tissues of the host.

Many evidences tend to show that presence of parasitic worms predispose the host to other disease. At times this seems to be due to the fact that the general vitality is lowered, making the host more susceptible to bacterial diseases. At least in some cases it is thought that the worms directly aid by mechanical inoculation of disease organisms. Turkeys, when fed on droppings from birds suffering from blackhead, do not always contract the disease while the incidence is high for those birds fed on worm larvae mixed with droppings.

One of the most serious obstacles to control measures is presented by the strong migratory habits of animals. Wild ducks and geese in a given sanctuary may show critical results of parasitic disease against which no local measures may be directed with success. The chances are strong that the parasites causing the disturbance were

secured in some far distant part of the range, on the breeding grounds or in the winter range. Only by widely coordinated studies, often involving international cooperative projects, can we hope to attack such problems with promise of satisfactory results.

In this paper chief attention has been directed to problems encountered in wildlife studies of birds and mammals. The reason for this is that in game management conditions which are not unlike those found in agricultural practice usually exist. The situation with reference to the recognition and control of dangerous parasites in fishes, however, is wholly different. Only in hatcheries and small ponds do conditions exist that permit of any sort of control. Except for a relatively small number of parasitic worms which pass part of their existence in fish and later become parasites of fish-eating birds and mammals (including man), the worm parasites of fishes have little medical or veterinary importance. This statement must not be construed to mean that fish parasites have little economic value. It is the opinion of the writer that parasitic worms have primary importance in determining the number and condition of fish in natural waters.

Under conditions found in hatcheries, rearing ponds, and private fishing preserves, excessive infestations are frequently built up, but the food supply is often under partial control and periodic drainage may be resorted to for checking dangerous outbreaks. At times the fish may even be treated in tanks much as in veterinary practice cattle are dipped. Often practices that cannot be sanctioned in a conservation program have been advocated. Among these, two will be mentioned as examples. The shooting of herons and other water birds has in the past been recommended as a means of avoiding grubs in fish, caused by the larvae of trematodes (Clinostomum) which live in the mouth and throat of herons. Destruction of snails, which are almost without exception a necessary host for trematodes, has likewise been advocated. Any biologist who understands the importance of molluscs in food chains and in the general economy of aquatic habitats would not seriously propose such a measure.

In the larger streams, ponds, and lakes, control of fish parasites, desirable as it might be, is not possible under our present state of knowledge. In recent years, information regarding the parasites of fishes has been rapidly accumulating but effective control measures are almost wholly lacking. Close to one hundred different species of worm parasites have been recorded from the fishes of a single lake. Many of these doubtless have significant effects on the growth and relative numbers of fish present in the lake but no means for controlling any one of these worms has ever been perfected. The study of worm parasites in fishes is still in its infancy. Even though there have been numerous researches for two generations, few have gone beyond the level of taxonomic, morphological, and distributional studies. Another generation may be able to find applications that will enable wildlife agencies to control the parasites of fishes in a measure comparable to the practices available in medical and veterinary science.

In any analysis of the factors limit-

ing the numbers of animals, available food supply, suitable habitats, predators, contagious disease, and climatic conditions are usually emphasized. The writer feels relatively certain that for many animals the internal parasites are just as effective as are these other factors in regulating the numbers of animals of any kind that may exist in a given area. When parasitologists and conservationists see the problems of host-parasite-habitat interrelationships in true perspective there will be opportunity for learning the place of animal parasites in determining periodic rhythms that have long perplexed students of populations.

The program of researches on wild birds and mammals should follow, so far as possible, the paths already laid out in the fields of medical and veterinary helminthology. In so doing the student must be independent and resourceful enough, however, to discern where his problem departs from the beaten path. From the scanty information available he must not assume that all worms encountered in game animals are different from those recovered from allied domestic animals, nor is he safe in assuming the opposite. He must be constantly on the alert to detect evidences of worm infestation and tireless in his efforts to discover and apply preventive measures.

To the student of fish parasites there is almost limitless opportunity for contributing to basic knowledge and perchance for devising control measures that have eluded students to the present time.

There is a challenge in the problems of worm parasites of wildlife which should enlist the closest cooperation of helminthologists and conservationists.

In conclusion, I wish to make a plea for closest integration of the work of scientific laboratories and conservation agencies. In many localities, research laboratories already established and operating are willing to perform routine autopsies and make diagnostic tests for agencies studying parasitic diseases of animals. Especially in regions where large mammals are concerned in the wildlife program it is desirable that trained parasitologists or helminthologists capable of making field studies and autopsies be on the staff. Where conditions do not permit of employment of such specialists, cooperative arrangements should be perfected, using whatever laboratory facilities are available in the region.

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NATURALLY SUSTAINED YIELD IN A FARM FUR CROP IN MISSISSIPPI

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The principle of sustained yield or the maintenance of continuous productivity in the management of natural resources was first applied in forestry, the practice beginning in Germany before 1600. In 1930 the Committee on Game Policy (3), under the chairmanship of Professor Aldo Leopold, defined game management as the art of growing game crops for recreational use. In 1933 Leopold (2) gave this definition in terms of sustained annual crops. The United States Forest Service, advocate of sustained yield in timber production since its establishment, is now putting big game production in the National Forests on the same basis. The sustained yield idea is still a recent concept in American wildlife circles, but its logic is so apparent that it is rapidly being accepted as axiomatic.

Innis (1) and others have shown that the Hudson's Bay Company, during a considerable part of the last century, actually achieved a relatively constant yield of furs. This was not a definite objective but a result due to circumstance instead of management. In reality, furs, especially beaver, were exterminated in places, and only the vast wilderness area apportioned between a limited number of hunters made possible a form of sustained annual yield.

More recently but on a much smaller scale, numerous fur farms through some system of artificial management are producing sustained annual fur crops while still maintaining the breeding stock. But the possibilities of sustained yield cropping of the fur resources under natural conditions are not generally appreciated by land owners. Some by chance are harvesting an annual crop of furs and at the same time leaving an adequate number of breeding animals, whereas others are practicing or permitting destructive cropping methods.

During the period between 1920 and 1926, the writer, without realizing it, harvested an annual and constant yield of furs from the family farm, and in doing so was returned the surprising compensation of $0.75 per hour, covering time spent in skinning, stretching, and shipping furs, as well as that on the trapline.

Description of Area and Farm Practices

The farm is located in Webster county, Mississippi, and is 80 acres in area. At the period referred to about 30 acres were cultivated or otherwise devoted to domestic use, and about 50 acres were in timber. Crooked Creek, a stream about 20 feet wide and nowhere more than 5 feet deep, ran through the tract (Fig. 1). In addition, 3 very small spring runs cut across the property and emptied into the larger stream. Crooked Creek flowed at all seasons, and the runs were reduced to holes only during the most prolonged drouths. Although normally clear, all these streams were muddy after heavy rains. Floods occurred yearly, the largest stream sometimes reaching a width of 200 yards or more, but it seldom remained

in this condition more than a day and night. High water generally occurred during the winter and spring, although occasionally it might follow heavy rains at any season. July, August and September were ordinarily the months of least precipitation and lowest water levels.

semi-virgin state. Many of the trees were 3 feet or more in diameter, and a considerable number of the gums and beeches, especially, were hollow or otherwise defective. Good stocking of lower age-class timber generally prevailed.

The entire 80 acres were enclosed by a 3-strand barbed-wire fence, and the

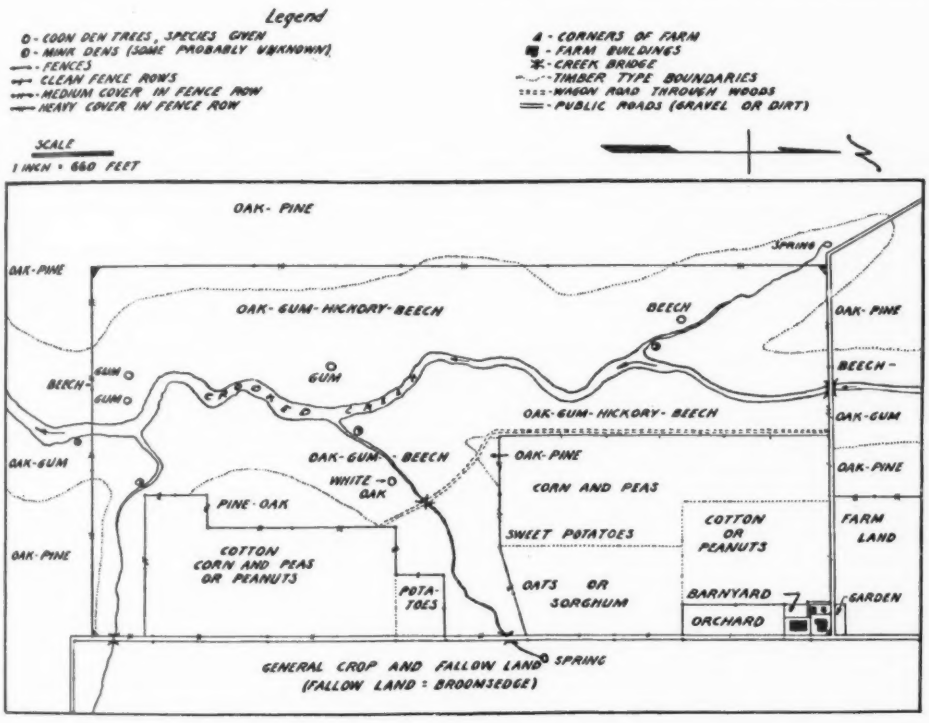

Fig. 1. Map of 80-acre farm in Mississippi, showing streams, timber types dens, crop lands and land adjacent to farm.

As shown in Figure 1, the timberland was mostly bottom hardwoods, chiefly red gum, beech, hickory, ash, and several species of white and black oaks. The only conifer of importance was short-leaf yellow pine (*Pinus echinata*). Some of the better white oak had been cut a decade or more before 1920; otherwise the hardwoods were still in the timbered area was lightly grazed by 4 or 5 head of cattle. No sheep, goats, or hogs were pastured at any time. Subsequent to the harvest and during a part of the winter months, the cattle were confined in the cultivated fields where better forage in the form of crop residues was available. The chief crops were corn, cotton, peas, peanuts, oats,

and sweet potatoes, rotated in somewhat this general order, except that cotton was never planted on the low, moist soil along the western edge of the cultivated area.

FAUNA OF THE AREA

The chief fur-bearing animals were raccoons, minks, and opossums. One red fox and one brown weasel, probably *Mustela peninsulae olivacea* Howell, were taken during the 5-year period of trapping. Other fur-bearers known to occur were the common and spotted skunks, probably *Mephitis elongata* (Bangs) and *Spilogale putorius* (L.), respectively, but they were never taken on the area by the writer. Muskrats occurred in small numbers about 3 miles to the south, in an area where extensive corn and oat fields extended to the bank of the creek. The deeply shaded creek in the heavily timbered areas contained little vegetation and probably a higher population of mink than the farmed sections. These two factors presumably account for the absence of muskrats on the forested part of the creek.

Other common mammals were fox and gray squirrels, flying squirrels, chipmunks, moles, shrews, deer mice, meadow voles, bats, and both swamp and cottontail rabbits. Wildcats did not occur on the area and gray foxes were very scarce or absent.

Songbirds, crows, hawks, owls, and bobwhite quail were common to abundant. In the creek and the deeper holes in the runs the fish population was abundant and consisted of minnows, suckers, sunfish, and catfish.

TRAPPING

The usual trapping procedures were followed in taking the fur crop. Both "bait" and "blind" sets were made in about equal numbers, using No. 1½ and No. 2 Victor traps. Each season a line of about 25 traps was operated from November 15 to January 1. Except during the brief floods, which averaged about one per trapping season, the traps were kept in good working condition. The annual catch averaged 48.6 animals for the 5-year period, and was as follows:

TABLE 1
THE ANNUAL TAKE OF FURS

Year	Opossum		Mink		Raccoon		Red Fox		Weasel		Total		
	No. and Sex		No. and Sex		No. and Sex		No. and Sex		No. and Sex		No. and Sex		M and F
	M	F	M	F	M	F	M	F	M	F	M	F	
1921	15	14	5	6	6	4	0	0	0	0	26	24	50
1922	13	14	7	5	3	5	0	0	0	0	23	24	47
1923	14	17	5	5	5	4	0	0	0	0	24	26	50
1924	10	16	4	6	3	6	1	0	0	0	18	28	46
1925	13	16	4	7	4	5	0	0	1	0	22	28	50
Totals	65	77	25	29	21	24	1	0	1	0	113	130	243

The above figures represent the annual yield on the 80-acre farm because, (1) only the furs taken on this area are included in the table, (2) no furs were drawn off adjacent areas as the writer's

trapping operations were fully as intensive for a half mile beyond the north and south ends of the farm as on the farm, and (3) outside of night-hunters getting not more than $4 or $5 worth of fur per year, the writer was the only person taking furs in the vicinity. There were no losses from stolen traps or furs. The owners' lack of interest in the wildlife resources kept them from closing their properties to hunting, fishing, or trapping.

As indicated in the last three columns of Table 1, a sustained fur crop was harvested each season during the 5-year period. It is reasonable to assume, therefore, that only the surplus animals, or the annual increase, were removed. This is an average of 28.4 opossums, 10.8 mink, 9 raccoons, 0.2 fox and 0.2 weasel per year.

As a basis for calculating the average yearly total population of fur-bearers, it seems safe to assume from Table 1 that the sex ratio for the three important species is 0.5, though mating in these 3 forms is almost certainly promiscuous. In the red fox, since it is monogamous, the sexes are evenly divided; and in the weasel it is probable that approximately equal numbers of males and females make up the population. All species listed produce young at one year of age, and have one litter annually. Conservative estimates indicate that the average size of litters for these fur-bearers are as follows: opossum-5, mink-4, raccoon-4, red fox-4, and weasel-4. Seton (4) indicates a higher average number of young per litter for these species. The average yearly total populations based on my figures are calculated in Table 2:

TABLE 2

THE AVERAGE YEARLY TOTAL POPULATION OF FUR BEARERS ON FARM[a]

Species	Average Annual Catch (Increase)	Ave. No. Young 1 litter	No. of Breeding Females	No. of Males and Females—0.5 Ratio	No. of Non-Breeders	Total Population
Opossum	28.4	5	6	12	?	40
Mink	10.8	4	3	6	?	16
Raccoon	9.0	4	2	4	?	13
Red fox	0.2	4	0.05	0.1	?	0.3
Weasel	0.2	4	0.05	0.1	?	0.3
Average total yearly population						69.6

[a] Number of breeding females calculated to nearest whole number except for red fox and weasel; fractions in "Average Annual Catch" omitted in additions giving "Total Populations" in final column, except in red fox and weasel.

It should be borne in mind that a conservative number of young per litter was used in this calculation and that the non-breeders of each species were not included. Thus, the average yearly total population was actually greater than indicated. It should be recalled also that this yield was obtained without any special attempt at management, except in the prevention of forest fires. Dogs ranged the farm freely, both winter and summer. No dens or shelters were provided or other environmental improvement made at any time. No food was artificially sup-

plied and no breeding stock was liberated. It should be added, however, that there was no scarcity of dens or food, and that cover and shelter was ample for all species. The elimination of free-ranging dogs and the small amount of outside hunting would undoubtedly have resulted in an increased yield in the annual fur crop.

Two additional factors in regard to trapping are important enough to justify mention. These are: (1) prevention of escapes from traps, especially "wring-offs," and (2) careful cleaning, skinning, and stretching of furs harvested. Good traps of ample size and strength should be used at all times, and to prevent "wring-offs" traps should be anchored in deep water whenever possible to cause drowning. Double-jawed and killer type traps are effective in preventing escape in the case of small animals like muskrat and mink. During the 5-year period considered, the writer lost only one animal by a "wring-off." This was a small mink which twisted off a front foot and escaped from a shallow-water set. About a half-dozen animals, chiefly mink, were missed during the 5 years due to failure of traps to secure foot holds in closing. This loss can scarcely be prevented; strong, quick-acting traps should reduce it to the minimum. Some of the animals so lost were probably taken later; the "wring-off" mink was never secured, though the animal escaped in 1922. It is probable that the mink died, thus representing a loss of $3.00 or more for the season. The ad-

TABLE 3

ACTUAL (1921–1925) AND THEORETICAL (1920– and 1926–1936) INCOME FROM FUR PRODUCED ON AN 80-ACRE MISSISSIPPI FARM[a]

Year	Opossum		Mink		Raccoon		Red Fox		Weasel		Total per Year
	Per Skin	Total	Per Skin	Total	Per Skin	Total	Per Skin	Total	Per Skin	Total	
1920	.95	26.98	6.50	70.20	6.00	54.00	14.75	2.95	.25	.05	154.18
1921	.50	14.50	3.20	35.20	2.80	28.00	5.00	.00	.10	.00	77.70
1922	.50	13.50	4.00	48.00	3.40	27.20	5.00	.00	.10	.00	88.70
1923	.65	20.15	4.45	44.50	3.65	32.85	7.00	.00	.20	.00	97.50
1924	.75	19.50	4.50	45.00	3.80	34.20	10.00	10.00	.50	.00	108.70
1925	.70	20.30	4.50	49.50	3.50	31.50	6.50	.00	.25	.25	101.55
1926	.70	19.88	5.00	54.00	5.00	45.00	6.00	1.20	1.00	.20	120.28
1927	.60	17.04	5.50	59.40	5.00	45.00	6.50	1.30	1.25	.25	122.99
1928	.75	21.30	5.50	59.40	3.75	33.75	7.50	1.50	1.25	.25	116.20
1929	.55	15.62	5.50	59.40	4.00	36.00	6.00	1.20	.40	.08	112.30
1930	.25	7.10	2.50	27.00	2.25	20.25	2.25	.45	.40	.08	54.88
1931	.20	5.68	2.50	27.00	2.25	20.25	1.50	.30	.40	.08	53.31
1932	.20	5.68	2.00	21.60	1.50	13.50	1.75	.35	.25	.05	41.18
1933	.20	5.68	3.00	32.40	2.00	18.00	2.50	.50	.40	.08	56.66
1934	.20	5.68	3.50	37.80	2.25	20.25	2.50	.50	.40	.08	64.31
1935	.20	5.68	4.00	43.20	2.50	22.50	2.75	.55	.30	.06	71.99
1936	.25	7.10	5.50	59.40	3.50	31.50	3.00	.60	.40	.08	98.68

[a] Columns headed "Per Skin" give values for "No. 1, medium" pelts, except during period 1921–1925 where the average of all skins sold each year is given. Values in columns headed "Total," except for period 1921–1925, are calculated to nearest cent. The 5% commission charged by some fur houses is not deducted from these values.

vantages of proper handling of furs will be discussed in the following section.

VALUE OF FUR CROP

In Table 3, the cash income from furs actually trapped on the farm, and also the theoretical income, based on an average of southern raw-fur prices for each year, are given for the boom period of 1920 and for the period of 1926–1936, inclusive. These data are shown graphically in Figure 2.

The average annual gross income during the 5 years was $94.83, or an average of slightly more than $1.18 per acre. The cost of trapping, except for time, was low, as no expense other than the cost of traps and shells used in killing bait was involved. These items, however, should be subtracted from the gross income in calculating the net income, and are as follows:

Gross income		$94.83
Cost of traps per year (original cost prorated over 5 years)	$1.50	
Cost of ammunition used in killing bait per year	1.00	
Total		2.50
Net average annual income		$92.33

The hours of work are as follows:

Pre-trapping work (pre-baiting, set location, etc.)	15.0 hours
Setting traps first day of season	10.0 "
Running trapline (average 1 hour per day for season)	44.0 "
Skinning, curing, and packing furs for shipment (1 hr. per skin)	48.6 "
Pulling, cleaning, and storing traps at end of season	5.0 "
Total time	122.6 "

The return per hour, therefore, was,

$$\frac{\$92.33}{122.6} = \$0.75+$$

Over the entire 17-year period for which data on fur values are given, the estimated average annual gross income per acre, based on the average catch over the 5-year period of actual trapping, is about $1.13. This 17-year period included years of very high and very low prices and therefore should be indicative of average conditions that might be expected over a similar time.

Careful handling of furs, as already indicated, would undoubtedly raise the per-acre income. This conclusion is based on a comparison of returns on well-handled skins with the average price for skins for the same year and of the same size and quality. Close examination of Table 3 will disclose that the annual returns for opossum, mink and raccoon during the years of 1921–1925, inclusive, are proportionately higher than the average prices for these skins for the same years. In making these comparisons, prime average-size pelts, which are graded as "No. 1, medium," were used. The furs taken during the 5 years were shipped to various fur companies in St. Louis, Chicago and New York.

The return of $0.75 per hour compares favorably with wage rates in the industrial field, and is many times higher than the hourly return received by farmers and land owners in the locality from their farming operations.

DISCUSSION AND MANAGEMENT SUGGESTIONS

It must be remembered that this example of sustained fur yield comes from creek-bottom land, a type representing only about 10% of the land in Webster and adjoining counties. Furthermore, the environment de-

scribed was somewhat exceptional in that none of the land bordering the creek was farmed. How much more favorable this environment was compared to the average of the creek-bottom type is not known, but the writer is certain that cornfield- and bush-bordered creeks, filled with the usual log debris, offer an excellent mink and muskrat trapping site, and the total farm area, and the average per-acre income from bottom-land furs can be placed conservatively at $1.00 per year, it follows that the average income for the total area should be about $0.10 per acre per year. To this should be added the small crop of opossum, weasel, fox, skunk and civet furs that could be taken from the upland.

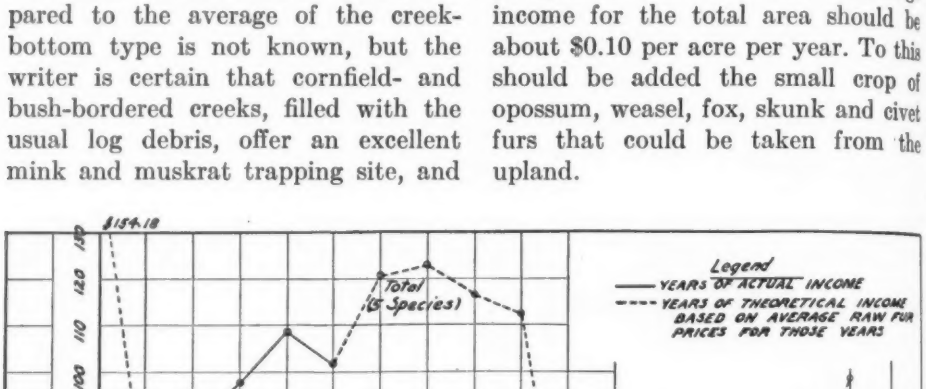

Fig. 2. Actual (1921–1925) and theoretical (1920– and 1926–1936) income from fur produced on an 80-acre Mississippi farm.

that opossums and raccoons freely use such areas. In cases where bottom lands are farmed, the absence of raccoon den trees is probably the most important limiting factor in the production of this animal, so common in southern farm sections.

If bottom land represents 10% of

In the general shortleaf pine regions, not more than 10 to 15% of the land is cultivated each year. About 85 to 90% of the land, therefore, is potentially productive of fur, as food, and cover (except for some scarcity of raccoon den trees) are not limiting factors. Very little of the land is de-

structively grazed. Most of the upland and a large part of the bottom land has been cut over, but except for raccoon this plays no permanent nor important part in reducing fur production. There are several reasons for this, namely, (1) that hollow, defective trees remain; (2) many hollow logs and tops are left on the ground; (3) quantities of brush are present; (4) repair by plant growth is rapid; and, (5) a greater variety of plant food is promoted by the resultant increase in light and space in cut-over areas. Cutting and the small-scale farming operations practiced on both upland and stream bottoms probably result in improved habitats for all fur-bearers except mink and raccoon, and for them the loss is not great.

As stated previously, muskrats occurred in considerable numbers about 3 miles south of the farm. They were most abundant along a section of the creek where corn fields extended to within a rod of the stream. Crooked Creek in the heavily timbered areas contained little vegetation, and this environmental factor plus the somewhat higher population of mink in the forested areas probably accounted for the general absence of muskrats in such sections. It seems probable that muskrats would tend to equalize the average annual per-acre income of farmed as compared to forested lands, as this species would respond to management fully as well as mink or raccoon. Damage caused by muskrats to corn and farm crops is usually not severe when natural foods are plentiful.

The advantages afforded by the shortleaf pine type for sustained fur crops and the probability that these extensive regions will long remain in a productive state, make it desirable that the fur crop be appreciated as a potential resource, particularly by the small land-owners. It would seem a simple matter to bring about conditions which would result in a greater fur production and consequently an increased rural income if the following program were instituted:

1. Visual or demonstrational education designed for rural classes to direct attention to the possibilities of fur production. Literature of suitable type might be distributed.
2. Distribution among interested land-owners of simple directions for the production and harvesting of the farm fur crop.
3. Reduction of forest fires.
4. Preservation of natural cover on land immediately adjacent to streams.
5. Erosion control to prevent the filling of streams and the consequent destruction of fish and vegetation, on which mink and muskrats, at least, are partially dependent.
6. Preservation of den trees, prevention of hunting or trapping out of season, and prevention of digging or chopping out of dens.
7. Regulation of free-ranging dogs, for in the South as well as in other regions dogs of all breeds, including half-starved hounds, roam freely day and night. The writer is certain that this results in the destruction of a large percentage of opossums and other fur-bearers during all seasons of the year.

The initiation and maintenance of a fur management program lies in the

range of possibility for every farmer and land-owner. There is nothing mysterious or involved to discourage those of limited training and the program has esthetic and recreational advantages. It is ecologically sound. Such a program would cost little but would add much by giving the small farmer and land-owner a much needed additional cash crop.

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AN ANALYSIS OF THE VALUE OF REFUGES FOR CYCLIC GAME SPECIES

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About ten years ago, when the game supply of New York State seemed to be failing before increased hunting, and the practice of posting private lands was alarmingly increasing, the sportsmen of the State began to urge the acquisition of lands by the State for game refuges and public shooting grounds. The theory was that a refuge, protected from hunting, would produce a surplus of game which would overflow into the surrounding public shooting grounds and furnish a constant supply of good hunting. It was further contended that game would seek protection in the refuge areas when hunted on the surrounding lands and thus an adequate seed stock would always be preserved. The cyclic nature of several of the "disappearing" species was then hardly recognized, let alone understood. At the outset, the slogan was "A game refuge for every county." Several of these areas were acquired by the State prior to the recent period of financial retrenchment.

The game refuge principle gained wide acceptance following its apparent success in certain parts of the country. Pennsylvania's remarkable increase in its deer population took place simultaneously with its large scale acquisition of wild lands for game refuges and public shooting grounds and this increase of deer was largely attributed to the game refuge policy. The Federal Biological Survey has demonstrated clearly the value of refuge areas for wild waterfowl. It was natural then to assume that this same technique would apply to the management of other species of game. The validity of this conclusion depends upon whether or not hunting is a decisively limiting factor for any given species.

The period of curtailment of funds brought a temporary halt to the game refuge acquisition program in New York. During these years the Conservation Department has had an opportunity to watch the progress of the first few refuge areas and has come to doubt the value of game refuges in the management of certain upland game. Particularly, preliminary field observations on cyclic species such as the ruffed grouse, cottontail rabbit, and gray squirrel seemed to indicate a lack of adaptability of these species to management by the refuge principle. It was therefore decided to make a thorough study of the value of refuges as game-producing units before incurring further expenditures for this purpose.

The study was made on two upland, abandoned farm areas in Chenango County, New York, the first being the Pharsalia Game Refuge and the second a similar area of public shooting grounds five miles away. The study areas were lands adapted to grouse, rabbits, squirrels and, to a lesser extent, deer. The public shooting area was studied for purposes of comparison with the refuge.

The Project Areas

The Pharsalia Refuge and the check area are typical of the hilly, abandoned farm land of southern New York.

The elevation runs from 1,200 to 2,000 feet, the soils are worn out and transportation facilities bad. The two areas are essentially similar in size, topography and cover, differing primarily in the fact that one is a refuge and the other a public hunting area, each marked as such. While some game food and shelter plantings had been made on the refuge area and coniferous reforestation begun on the check area, none of these had attained sufficient growth to affect our problem. Some predator control had been practiced on the refuge while the check area had only the haphazard predator control that hunters give. The effect of these practices on the problem at hand also is not significant.

The refuge had been effective as such for a period of five years prior to the beginning of the study. The check area had been open to public shooting as private land indefinitely prior to the study and had been marked as "Public Hunting Grounds" for a year when our work began.

Hunters flock to this region from the nearby cities of Binghamton, Cortland, and Norwich as well as from numerous small communities in the vicinity. While no field check of the degree of hunting pressure was made, the area lies in one of the best upland hunting sections of the state. There is no doubt but that the hunting pressure was at least average on this area.

The area of the refuge is 2,120 acres while that of the check area is 1,893, a difference of 227 acres. Excluding the open land, however, the acreage of cover is 1,340 and 1,378 respectively, a difference of 38 acres, or 3% more on the check area than on the refuge. Since the amount of open land covered by the survey (just a 100 foot belt around the cover) was the same on both areas, the data obtained are essentially comparable.

A comparison of the cover types on the two areas revealed a slight excess of brushland and hardwoods on the refuge as compared with the check area and a corresponding excess of mixed woods and slashing on the check area. Since the surveys were conducted in the winter, the somewhat greater amount of mixed woods on the check area would give it better winter conditions for grouse than existed on the refuge. However, there were no real deficiencies in any type in either case. Further, the distribution of the types was also comparable. The cover within each area was essentially independent of surrounding lands. Thus, the data obtained on the two survey areas may be considered justly comparable from the ecological standpoint, subject only to a 3% correction for size.

SURVEYS MADE AND METHODS USED

Three surveys have been conducted on the Pharsalia areas, all in winter, the first in 1935, the second in 1936 and the last one this past winter (1937). The complete strip method, embracing all of the coverts, was used throughout with a crew of from three to six men. The crew was made up of a game technician, trained in census work on the New York ruffed grouse investigation, assisted by carefully selected C.C.C. boys.

Field work on the Pharsalia areas totalled 3,246 man-hours, equally di-

vided between the refuge and check area. Reduced to a per-acre basis, the first survey spent .29 man-hours per acre on the refuge area to .28 on the check area; the second survey consumed .43 and .45 man-hours per acre, while the third took .47 and .45 man-hours per acre, respectively. Each area was covered three times per survey and the four sections into which each area was subdivided were worked alternately to offset any changes in weather conditions.

GAME POPULATIONS ON THE PHARSALIA AREAS

Ruffed Grouse

Data on grouse populations for the refuge and check area for the three years are summarized in Table 1 on this page.

TABLE 1

RUFFED GROUSE DATA—PHARSALIA SURVEY—1935, 1936 AND 1937

Type of Data	1935		1936		1937	
	Refuge Area	Check Area	Refuge Area	Check Area	Refuge Area	Check Area
Grouse Flushed	438	537	301	289	349	465
Grouse Tracks	740	765	257	592	480	489
Grouse Droppings Locations	207	298	231	723	247	338
Grouse Kills Found	11	9	24	21	2	5
Estimated Grouse Populations	166	252	134	135	117	163
Acres of Cover per Grouse	8.1	5.5	10.0	10.2	11.5	8.4

In comparing these data, it is at once noted that the refuge, instead of producing a greater supply of grouse, actually had fewer birds than the check area in two of the three years. In 1935, the refuge had only 66% as many grouse as the public shooting area while in 1936 the populations were practically identical. Then in 1937, while the grouse population on the refuge continued to decrease, that on the check area increased and had 39.3% more birds than did the refuge. While the densities have essentially the same ratios as the populations, the 1936 population densities on both areas were considerably lower than those of the previous year. But in 1937 the density of grouse on the public shooting area showed a marked increase while that on the refuge continued to decline. While it is outside the province of this paper to delve into the explanation of these losses and recoveries, suffice it to say that they are not related to the refuge problem.

If winter shelter, as represented by the coniferous portion of the woodland composition, is a limiting factor for grouse, the discrepancies in grouse numbers on the two areas is at least partially accounted for. While this limiting factor unquestionably operates on shelter-deficient areas, it is certainly not of first importance on areas so abundantly supplied with shelter as are both of those in question. Thus, while analysis of the effect of the small differences in the areas may serve to explain some of the variations in grouse numbers, the fact still remains that the

protection afforded by the refuge during the period concerned did not serve to enlarge the crop of grouse.

Cottontail Rabbit

Since census methods are not well adapted to the rabbit population, more weight must be given to sign than to sight records. Further, since no satisfactory means have been evolved for the determination of rabbit populations from such field data, all comparisons must be of the data itself. Taken in a comparable manner and under similar conditions, they should correctly indicate trends.

Table 2 summarizes the field data on rabbits for the refuge and check area. Based on the scanty sight records, the refuge had more rabbits than the check area in 1935 and in 1936 but in 1937 the check area had more than the refuge. However, these records are too few for reliable use. Using the tracks recorded as an index, we find 50% more rabbits on the refuge in 1935 but in 1936 the check area showed 2.4 times as many as the refuge. Then again in 1937 the check area records exceeded those on the refuge, this time by only 15.6%. Thus, while the refuge decreased markedly in its rabbit population from 1935 to 1936, the check area population was considerably increased. In 1937, both areas had suffered a marked decline with the net balance of animals remaining about the same on the two areas. Such inconsistency renders conclusions difficult but it is clear that the protection given by the refuge is not capable of maintaining a stable population or of giving consistently higher production of this violently fluctuating species.

TABLE 2
COTTONTAIL RABBIT DATA—PHARSALIA SURVEY—1935, 1936 AND 1937

Type of Data	1935		1936		1937	
	Refuge Area	Check Area	Refuge Area	Check Area	Refuge Area	Check Area
Rabbits Started	25	18	24	8	8	9
Rabbit Tracks	1,071	713	589	1421	224	259
Rabbit Kills Found	5	3	9	19	3	1

Gray Squirrel

Here again, tracks rather than sight records must furnish the primary basis of study—and the estimating of actual populations is beyond our present ability. Data on gray squirrels for the surveys are summarized in Table 3.

TABLE 3
GRAY SQUIRREL DATA—PHARSALIA SURVEY—1935, 1936 AND 1937

Type of Data	1935		1936		1937	
	Refuge Area	Check Area	Refuge Area	Check Area	Refuge Area	Check Area
Gray Squirrels Seen	9	7	0	0	1	0
Gray Squirrel Tracks	1,172	834	371	390	107	75
Gray Squirrel Kills Found	0	0	0	3	0	0

This species, plentiful in 1935, had become scarce on both areas in 1936. The protection of the refuge was unable to prevent this loss. And, while the refuge showed a 40% greater population (as measured by track sign) than the check area in 1935, the check area had a slightly greater number in 1936. By 1937 both areas had suffered further losses, with the refuge having a somewhat higher survival than the check area. It is interesting to note that in the two year period between the first and third surveys, the refuge had lost 90.9% of its gray squirrels and the public shooting area had lost 91.0%. The slightly greater survival of squirrels on the refuge as well as its greater 1935 population is explained on the basis of a higher carrying capacity due to the slight excess of hardwood cover on the refuge compared with the check area. Here again, no value can be attributed to refuges as a means of maintaining game of this type.

CONCLUSIONS

From the results of this study to date, the conclusion must be drawn that refuges are of no value in maintaining populations of cyclic species such as the ruffed grouse, cottontail rabbit, and gray squirrel; fluctuations continue regardless of the protected or unprotected status of the coverts. Whether or not refuges are of value in assisting these species in their recovery from the scarcity phase of the cycle will be determined as the study continues.

The possible function of a refuge for preserving seed stock on areas that have an *abnormally* high hunting pressure, as those near large cities, has not been tested, but the present study would seem to indicate that such areas would only function to prevent extermination, not as a means of furnishing continued hunting on surrounding lands.

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USE OF MECHANICAL BRUSH-CUTTERS IN WILDLIFE MANAGEMENT

Herbert L. Stoddard

One of the most expensive and time-consuming operations involved in large-scale wildlife management is the reclamation of brush-choked land where open areas and herbaceous vegetations are required. And this problem is not faced by the wildlife manager alone, but as frequently by the forester who would bring in pine (either through artificial planting or natural reseeding) where dense undergrowth composed largely of "weed" species occupies the terrain, by the stockman who wants to develop pasturage where similar conditions prevail, and by the agriculturist for various purposes. Nor is the need for brush control confined to the humid Southeast but is prevalent also where various sorts of jungle exist, even in arid parts of the West. The problem is discussed here, however, with relation to conditions prevailing in the Southeastern pine belt.

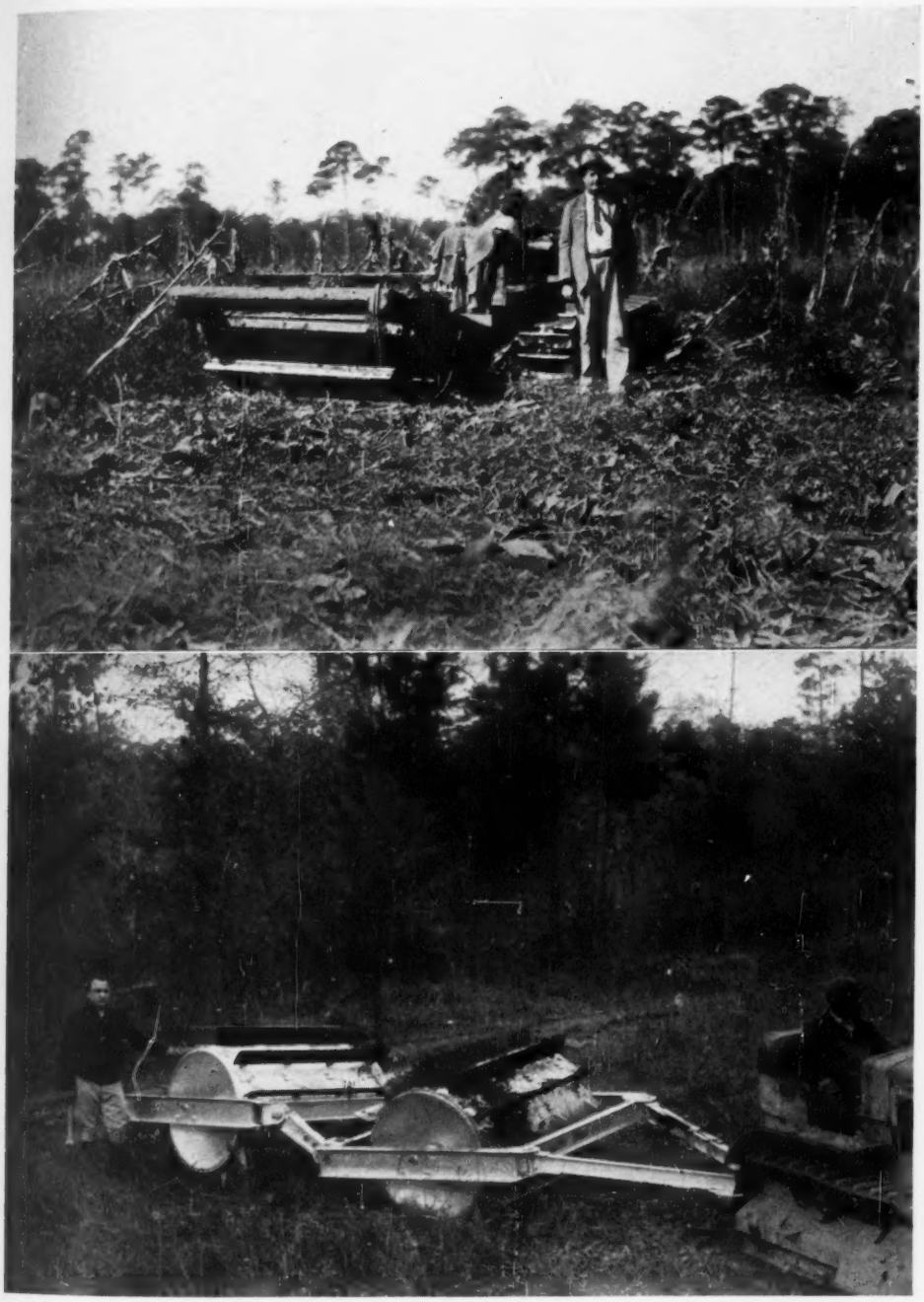
In this region large areas have been, and are being, acquired and managed primarily for such upland game as quail and wild turkey, with secondary emphasis on forestry and farming. Here ideal game and hunting conditions may be in pine forest, though for best results the forest *must* be maintained in an open parklike condition with largely herbaceous ground vegetation and just enough thicket growth in island-like coverts to furnish the birds protection when pursued by winged enemies. Such cover is particularly necessary for quail as the Cooper's and sharp-shinned hawks ("blue darters") which are among their most efficient enemies, are best defended against by an abundance of well distributed escape coverts.

Where pinelands are already open and free of objectionable deciduous undergrowth such as oak and sweet gum, it is a comparatively simple matter to maintain them in this condition by proper use of controlled fire, as has been discussed in detail elsewhere.[1]

It frequently happens, however, that lands acquired for game preserves are the cheapest available, and contain much cut-over, jungle-choked territory. Attempts to open up such land with brush hook and ax are frequently hopeless, and even where hand operations are supplemented by controlled fire, it may cost more than the original purchase price to bring the tract into the desired condition. After de-brushing by manual labor, there is no assurance in many cases that the operation will not have to be repeated every two or three years, for cut-off gum and oak may sprout so vigorously from the stump as to suppress by shading the grasses and sedges that are depended upon to "carry" the fire necessary to final subjection of the brush and thus long delay the desired conversion to herbaceous vegetation.

The first mechanical brush-cutter, which came to the writer's attention, was a crude affair built near Beaufort, S.C., more than twelve years ago. It consisted of the turned heart of a pine log about five feet long and some three feet in diameter, to which were bolted

[1] Stoddard, Herbert L. The Use of Fire on Southeastern Game Lands. Cooperative Quail Study Association, Thomasville, Ga., 19 pp., 1935.

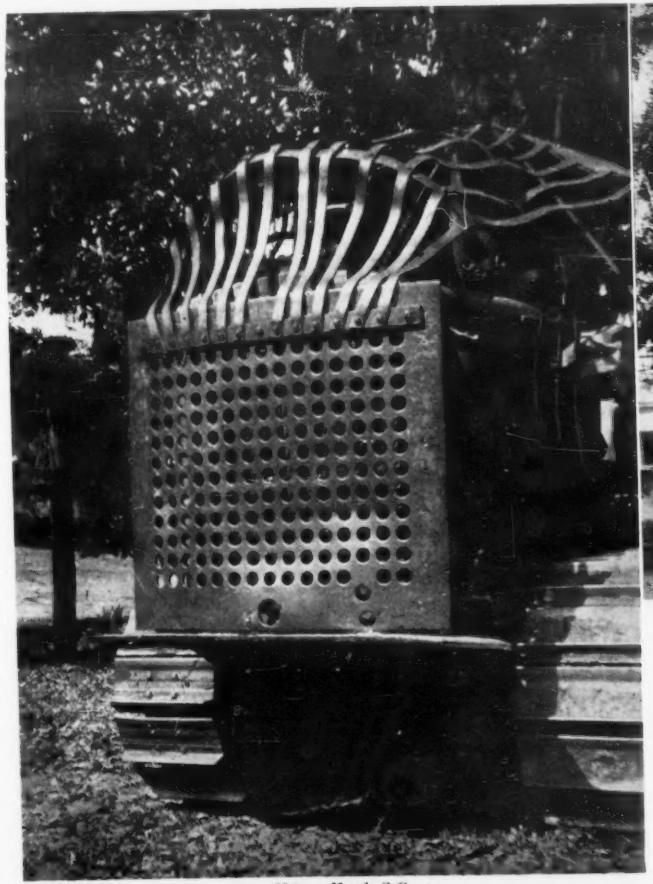


A. (*Upper*)—Brush-cutter in cover crop. E. W. Goldenstar who developed it.

B. (*Lower*)—Marden Duplex Brush-cutter. Marion G. Denton its designer.

A. (*Upper*)—Forward unit of Marden Brush-cutter, drawn by tractor with special radiator guard.

B. (*Lower*)—Work of Marden Brush-cutter in heavy brush.



A. (*Left*)—Tractor with ventral plate, radiator guard, and steel cage to protect the driver.

B. (*Above*)—Side view of same tractor showing steel cage and roof to protect the driver.

Photos Courtesy Ted Armstrong, Hilton Head, S.C.

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about a foot apart used veneer knives about six inches deep and running the full length of the log. The frame in which the axles turned was of wood, and the machine was pulled by a heavy team. This machine did very good work in cutting-in cover crops or demolishing low bushes, but could not stand up under long-continued heavy usage.

A further step forward was made by E. W. Goldenstar, manager of Buckfield Plantation near Yemassee, S.C., who developed a cast metal drum to which the veneer knives were securely bolted. The axles of the drum were socketed in massive oak frames, and the machine operated with a twenty horsepower track-type tractor did splendid work in heavy brush as well as in cover crops. Plate 1-A shows Mr. Goldenstar with one of several of these machines which he built and operated on Buckfield Plantation.

Through the combined efforts of Mr. Goldenstar and the Walterboro Iron Works of Walterboro, S.C., this brush-cutter has recently been further perfected. It is now obtainable with a durable all-metal frame and heavy metal drums to which are bolted about a foot apart very durable steel knives (road machine blades rolled flat). The diameter of the drum is two feet six inches without the knives. The blades are five feet long and five and a half inches wide, and twelve of them are usually fixed on each drum. The total weight of such a brush-cutter is approximately 3,300 pounds. This machine can be built to order for between three hundred and four hundred dollars, depending on the prevailing cost of materials. Many of them are being operated with excellent results on preserves in the vicinity of Yemassee.

While this formidable machine was being evolved in South Carolina, another form of brush-cutter was independently developed in Florida by Marion G. Denton of the Marden Manufacturing Company, Auburndale, Fla. The Marden Duplex machines were first built and used as cover crop cutters in citrus groves. When drawn in tandem, the drums set at angles had great effectiveness; but they could be operated side by side also to cover more ground in lighter going.

As soon as demand developed, this machine was built in a form adapted to the heavier work involved in jungle and scrub palmetto control. Plate 1-B shows one of these machines being operated in tandem, Plate 2-A with first section only, which is sufficient for all but the heaviest work, and Plate 2-B the result of its use in heavy brush land.

Some specifications of the Marden Duplex Brush Cutter are: Drums 39 in. in diameter; knives of double-bevelled stalk-cutter steel ½ by 6 in. and 5 ft. long; machine entirely of steel, electrically welded, with Timken bearings and Alemite system; completely flexible and adjustable as to weight, depth of cut, and angle of cut; weight empty about 4,000 pounds (two units); the weight can be approximately doubled by filling the drums with water. A twenty horsepower tractor can easily operate the forward unit alone but for both units filled with water a "thirty" is preferable. The cost complete with two cutting units has been $760.00; forward unit only $435.00, though prices are naturally subject to variation to correspond with those of materials. Special advantages of this machine are adjustability, reversibility

of the blades, and excellent bearings.

Radiators, crank cases and other vulnerable parts of tractors used in operating brush-cutting machines should be protected by specially designed guards, and sometimes it is necessary also to protect the operator by a network of steel bands in especially heavy going. Track-type or "caterpillar" tractors are best adapted to this work, though wheel-type machines are sometimes used. One of the best equipped tractors seen was a 35 horse-power Diesel-engined machine, Plate 3, on Hilton Head Island, S.C. This not only had the driver completely protected by a sturdy cage and the radiator shielded by a heavy screen but there was a thick sloping plate fastened under the front so that the tractor could without damage ride down every thing in its path. It was in principle a "tank" and the way it went through woodland including trees 4 to 6 inches in diameter was a revelation. The brush-cutter following reduced everything to kindling. The sun soon dried this and fire did the rest. The result was open land for operations of the wildlife manager where only a few days before was unmanageable, even impenetrable, jungle.

Brush cutting may be carried on at any season of the year but late summer and fall are best, as deciduous growth seems most easily killed when in full leaf. As the knives may penetrate up to seven inches, lateral roots are largely severed, and where the machines are run both lengthwise and crosswise, most of the roots are well cut and turned up where they can be burned along with other debris. In practice brush-cutters are seldom depended upon alone in the reclamation of "jungle," fire usually being employed as soon as the debris is dry enough to burn.

Cherry, flowering dogwood, persimmon, plum, and other trees and shrubs it is desired to save can of course be spared by the operator, though care must be used if undue damage to their root systems is to be avoided.

The severe soil scarification resulting from the use of brush-cutting machinery greatly stimulates growth of herbaceous vegetations, especially when fire is used following the cutting, for the ashes have much the effect of an application of fertilizer while the heat improves the germination of hard seeds. Of course the vegetations that appear following brush-cutting depend on the sorts of viable seeds or living roots that have survived from some previous time when the land was in more open condition. Native perennial legumes seem especially adapted by Nature to carry through long adverse periods both in the form of viable hard seeds and dormant, though living roots. We seldom know just what combinations of vegetation to expect, though this may be determined in advance of general brush-cutting operations by the opening of experimental lanes through areas under consideration, and study of the vegetations appearing.

While cost of equipment and operation prohibits the use of the machinery here described for small scale environmental control, it is extremely economical as compared to hand work when the improvement of areas involving thousands of acres is required.

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NOTES

Cover Design

The field covered by wildlife management is extensive, including as it does animals and their environment. When an attempt was made to design a cut for the cover of the new Journal, it was found impossible to include in a simple, well-composed design representations of all the important elements involved in the wildlife field. Such a representation was therefore abandoned and a brief study was made of symbols and pictorial writing.

As pre-Columbian Americans thought of the various kinds of animals and plants as entirely distinct beings, without connection in functions or structure, their pictorial forms of representation did not, seemingly, include comprehensive symbols for the larger groups, comparable to our classes or phyla. Next Egyptian hieroglyphics were considered by Victor H. Cahalane, our Secretary, as a possibility. J. E. Lodge, Curator of the Freer Gallery of Art in Washington very kindly pointed out several appropriate words and furnished photographs of them. They were then reproduced in a pen and ink drawing by Walter A. Weber, artist of the National Park Service. The editor wishes to acknowledge with appreciation the gift of time and thought to this matter by Messrs. Cahalane, Lodge, and Weber.

The literal translation of the words, from top to bottom is as follows: beasts, birds, fishes, flowering plants.

Charter Membership

Notice is given by the Secretary that the deadline for Charter Membership is September 1, 1937. Persons mailing their applications for membership prior to midnight of that date will, if accepted, be recorded on the list of charter members. The designation will be applicable to associates and will be retained by those who may later be elected to the active classification.

Long Live the Wildlife Society!

There is nothing in the entire field of American wildlife conservation that is more badly needed than consolidation of the group of wildlife specialists that has grown from the mere dozen that attended the first meeting of the research group in New York some years ago to the hundreds that are now employed throughout the land. It may well be added that the growth of this group is the most hopeful contemporary feature of American wildlife conservation. It may confidently be said, furthermore, that upon the practically functioning solidarity of this group, and the achievement of its objective of the development of all types of wildlife management along sound biological lines, absolutely depends the future of the conservation movement in this country and the perpetuation of our wildlife resources.

The need is great, the aim is high, and a thoroughgoing professional organization is required. With the example of the Society of American Foresters, and of its achievements, before us, hopes for success are high. The Society of Foresters has higher dues than ours yet has a membership of nearly 4,000 not to mention 5,000 sub-

scribers to its *Journal*. By having men independent of political influence on its Board and among its officers, some of the latter full-salaried employees of the Society, it is able to express its views without fear or favor, to contend publicly for what it considers right, and to defend effectively the interests of its members.

What the Society of American Foresters is doing in its sphere The Wildlife Society should do in the field of wildlife conservation nor is it too soon to begin; recent rapid expansion in wildlife employment emphasizes the need for organization and for policy making. The domain is not limited as it borders every field of American wildlife conservation. The goals of membership and influence achieved by the Society of American Foresters are not at all impossible of attainment for The Wildlife Society. Even now wildlife management is extensively practised in our forests. Part of this work will be done by foresters but they will be eligible for membership in our group and probably will be glad to affiliate. Wildlife specialists will be employed in increasing numbers and in time there will be staffs of wildlife managers on every public forest. National, state, and private forests, estates, hunting grounds of all types, game refuges, bird reservations, National Parks, and demonstration projects of the Biological Survey, Soil Conservation Service, and Resettlement Administration, all are places where wildlife management must be practised. It is an objective of The Wildlife Society to see that such management is carried on according to the highest standards by personnel that has had adequate professional training, and every person so employed should be an active member of the Society. Consummation of the objectives of The Wildlife Society is not only professionally desirable but will assure the highest possible standards in all phases of American wildlife conservation.—W. L. M.

EMPLOYMENT SERVICE OF THE WILDLIFE SOCIETY

According to the Constitution adopted at the 1937 St. Louis meeting, one of the major concerns of the Society is the "interests of its members." Clearly one important interest is in securing positions, or changes of position, for which members are equipped by training and experience. In recognition of this, the Society will establish an Employment Service in the October, 1937, issue of THE JOURNAL OF WILDLIFE MANAGEMENT.

Purpose: This service will be operated as a department of the JOURNAL for the dual purpose of (1) publishing information concerning available positions from prospective employers and (2) publishing the qualifications of persons seeking such positions.

Limitations: Appointments to nearly all federal and many state positions in wildlife management are based upon Civil Service ratings. Aspirants should therefore apply to the U. S. Civil Service Commission, Washington, D.C., or to corresponding state organizations for announcements of examinations. The JOURNAL will call attention to proposed tests as information about them becomes available.

Procedure: Each member will be entitled to one five-line statement of his education, qualifications, and preferences as to type of position in each volume. Additional lines will be charged for at the rate of 5 cents per line, and additional insertions at the same rate for all lines required.

Appointing officers are invited to report vacancies and new positions to the Appointment Service.

All communications for the Employment Service should be sent to the Editor, W. L. McAtee, Bureau of Biological Survey, U. S. Dept. of Agriculture, Washington, D.C.